G. Dundas

fm
2.50

THE

BOTANICAL TEXT-BOOK.

THE
BOTANICAL TEXT-BOOK,

FOR COLLEGES, SCHOOLS, AND PRIVATE STUDENTS:

COMPRISING

PART I.

AN INTRODUCTION TO STRUCTURAL AND PHYSIOLOGICAL BOTANY.

PART II.

THE PRINCIPLES OF SYSTEMATIC BOTANY;

WITH AN ACCOUNT OF THE CHIEF NATURAL FAMILIES OF THE VEGETABLE KINGDOM, AND NOTICES OF THE PRINCIPAL USEFUL PLANTS.

SECOND EDITION,

Illustrated with more than a Thousand Engravings on Wood.

By ASA GRAY, M. D.,

FISHER PROFESSOR OF NATURAL HISTORY IN HARVARD UNIVERSITY.

NEW-YORK:

WILEY AND PUTNAM.

1845.

CAMBRIDGE:
METCALF AND COMPANY,
PRINTERS TO THE UNIVERSITY.

TO

JACOB BIGELOW, M. D., F. L. S.,

PROFESSOR OF MATERIA MEDICA IN HARVARD UNIVERSITY; AUTHOR OF THE FLORULA BOSTONIENSIS, AND OF THE AMERICAN MEDICAL BOTANY,

THIS VOLUME

IS

RESPECTFULLY INSCRIBED.

Books 38 Oxford St London
" on Botany Rev Dr John's book
" Nat History Gayen Baill 22 Bedford St [illegible]

PREFACE.

This compendious treatise is designed to furnish classes in our schools and colleges with a suitable text-book, as well as private students with a convenient introductory manual, adapted to the present condition of botanical science. The first edition was necessarily prepared in great haste, and rapidly carried through the press. Still, the favor with which it has been received, not only by those for whose use it was intended, but also by botanists whose opinions may well be deemed decisive, and whose commendation was no less gratifying because unexpected, while it has satisfied the author that the plan of the work is well adapted to the end in view, has made him the more desirous to improve its execution, and to render it in all respects a better, though a very concise, exponent of the present state of Physiological Botany. The author has always maintained that Systematic Botany can be studied to any adequate purpose only when grounded upon the principles of Vegetable Organography and Physiology. The latter not only claim the earliest and highest attention of the general student on account of their fundamental nature, and their intrinsic importance, but must, indeed, almost monopolize the limited time that can usually be devoted to this department of Natural History in our colleges and academies.

In accordance with these views, the first part of the work, which relates to Structural and Physiological Botany, has been amplified to nearly twice its former extent. It has been almost entirely rewritten; but although the author has not hesitated to treat of all the principal topics of this department, as far as is practicable in a brief and strictly elementary treatise, yet this part of the volume, instead of having been rendered more abstruse by the enlargement, will rather be found to be more simple and generally intelligible than before. The chapters upon the Principles of Classification, and of the Natural System, have also been recast and somewhat enlarged. The want of space has alone prevented a more considerable extension. On the other hand, the Illustrations of the Natural Orders (which, however extended, could never take the place of a Flora, or System of Plants, and which is designed only to give a general idea of the distribution of the vegetable kingdom in great groups or families, &c.) have been condensed, by the omission of certain special, and for the most part medical matters; while every thing of proper botanical interest has been sedulously retained. The whole number of pages has been increased by about one quarter; and the illustrative wood-engravings have been doubled.

All the technical words employed throughout the volume are accentuated in the Index.

Harvard University, March, 1845.

CONTENTS.

PART II.

THE

BOTANICAL TEXT-BOOK.

INTRODUCTION.

GENERAL SURVEY OF THE SCIENCE.

1. Botany, the Natural History and Physiology of the vegetable kingdom, comprehends every scientific inquiry that can be made respecting plants, — their nature, their kinds, the laws which govern them, and their office in the general economy of the world, — their relations both to the lifeless mineral kingdom below them, from which they draw their sustenance, and to the animal kingdom above, to which in turn they render what they have thus derived.

2. There are three aspects under which the vegetable world may be contemplated, and from which the various departments of the science naturally arise. Plants may be considered, firstly, as individual beings; secondly, in their relations to each other, as collectively constituting a systematic unity, a *vegetable kingdom;* and thirdly, in their relations to other parts of the creation, — to the earth, — to animals, — to man.

3. Under the first aspect, that is, when our attention is directed to the plant as an individual, we study its nature and structure, the kind of life with which it is endowed, the organization through which this life is manifested; — in

other words, how the plant lives and grows, and accomplishes the ends of its existence. This is the province of PHYSIOLOGICAL BOTANY. It comprises a knowledge, 1st, of the intimate structure of the plant, the minute but admirable machinery through which its forces operate; — this is the special field of VEGETABLE ANATOMY; — and, 2d, of the plant's external conformation, the forms and arrangement of the several organs of which it is composed, the laws of symmetry which regulate them, and the modifications they respectively undergo, whether in different plants under different circumstances, or in a single individual during the successive stages of its development. This branch of the science is variously called ORGANOGRAPHY (the study of the organs of plants), or MORPHOLOGY (the study of their various modifications according to the office they are destined to fulfil), or STRUCTURAL BOTANY; and nearly corresponds with what is termed Comparative Anatomy in the animal kingdom. Under both these aspects, (whether we study the *inward structure*, or the *outward conformation*,) the plant is viewed as a piece of machinery, adapted to effect certain ends. It only remains to contemplate this apparatus in action, endowed with life, and fulfilling the purposes for which it was constructed. This study is the province of VEGETABLE PHYSIOLOGY, strictly so called.

4. The subjects which Physiological Botany embraces, therefore, namely, Vegetable Anatomy, Organography, and Physiology, spring naturally from the study of vegetables as individuals, — from the contemplation of an isolated plant throughout the course of its existence, from germination to the flowering state, and the production of a seed like that from which the parent stock originated. These branches would equally exist, and would form a highly interesting study, (analogous to human anatomy and physiology,) even if the vegetable kingdom were restricted to a single species.

5. But the science assumes an immeasurably broader interest, when we look upon the vegetable creation as consisting, not of interminable and wearisome repetitions of one particular form, in itself however perfect or beautiful, but as composed of thousands of species, all constructed upon the same general plan, indeed, but this plan modified in each according to the rank it holds, and the circumstances in which it is placed. This leads to the second great department of the science, namely, SYSTEMATIC BOTANY, or the study of plants in their relations to one another; as forming a *vegetable kingdom*, which embraces an immense number of species, differing in some respects, agreeing in others, and therefore capable of being grouped into *kinds* or *genera*, into *orders*, *classes*, &c.

6. Hence arises CLASSIFICATION, or the arrangement of plants in systematic order, so as to show their relationships; also SPECIAL DESCRIPTIVE BOTANY, embracing an orderly account of all known plants, designated by proper names, and distinguished by clear and exact descriptions. Necessarily connected with these departments is TERMINOLOGY or GLOSSOLOGY, which relates to the application of distinctive names or terms to the several organs of plants, and their different modifications. This requires the introduction of a copious vocabulary of technical terms; for the current words of ordinary language are not sufficiently numerous or precise for this purpose. New terms are therefore introduced, for accurately expressing the great variety of new ideas to which the close investigation of plants gives rise; and thus a technical language has gradually been formed, by which the botanist is able to describe the objects of his study with a perspicuity and brevity not otherwise attainable.

7. These several departments include the whole natural history of the vegetable kingdom, considered independent-

ly. But, under a third point of view, plants may be contemplated in respect to their relations to other parts of the creation, leading to a series of interesting inquiries, which variously connect the science of Botany with Chemistry, Geology, Physical Geography, &c. Thus, the relations of vegetables to the mineral kingdom, considered as to their influence upon the soil and the air, — as to what vegetation draws from the soil, and what it imparts to it, what it takes from, and what it renders to the air we breathe; and again, the relations of the vegetable to the animal kingdom, considered as furnishing sustenance to the latter, and the mutual subservience of plants and animals in the general economy of the world, — all these inquiries belong partly to Chemistry, and partly to Vegetable Physiology; while the practical deductions lay the foundation of scientific agriculture, &c. The relations of plants to the earth, considered in reference to their natural distribution over the surface of the globe, and its causes so far as dependent upon the actual distribution of those natural agents which chiefly influence vegetation, such as heat, light, water, &c., or, in other words, upon climate, give rise to GEOGRAPHICAL BOTANY, a subject which connects Botany with Physical Geography. Under the same general department naturally falls the consideration of the changes which the vegetable kingdom has undergone in times anterior to the present state of things, as studied in their fossil remains, (a contribution which Botany offers to Geology,) as well as of those changes which man has effected in the natural distribution of plants, and the alterations in their properties or products which have been developed by culture.

8. Of these three great departments of the science, that of Physiological Botany, forming as it does the basis of all the rest, first demands the student's attention.

PART I.

STRUCTURAL AND PHYSIOLOGICAL BOTANY.

9. The principal subjects which belong to this department of Botany may be considered in the most simple and natural order, by tracing, as it were, the biography of the vegetable through the successive stages of its existence,— the development of its essential organs, *root*, *stem*, and *foliage*, the various forms they assume, the offices they severally perform, and their combined action in carrying on the processes of vegetable life and growth. Then the ultimate development of the plant in flowering and fructification may be contemplated,— the structure and office of the flower, of the fruit, the seed, and the embryo-plant it contains, which, after remaining dormant for a time, (perhaps for years,) is at length aroused by the influence of common physical agents, (warmth, air, and moisture,) and in germination developes into a plant like the parent; thus completing the cycle of vegetable life. A preliminary question, however, presents itself. To understand how plants grow, and form their various parts, we must first ascertain *what plants are made of.*

CHAPTER I.

OF THE ORGANIC ELEMENTS OR TISSUES OF PLANTS.

§ 1. Of Organization in General.

10. In considering the materials or elements of which vegetables are made, we do not at present inquire into their *chemical*, *ultimate* composition, that which they have in common with the mineral world. As they derive the materials of their fabric from the earth and air, they can possess no simple element which these do not contain. Their chemical composition may be more advantageously considered hereafter. But in plants and animals, — in every thing that lives and grows, — though the elemental dust from which their bodies spring, and to which they return, is common earth, yet we perceive that it is wrought into something widely different from any form of lifeless mineral matter. The term universally employed to designate it well expresses this idea. It is *organized matter*, a fabric built up under the influence of the inscrutable principle of life, and through which alone this principle is manifested to our senses. Every one is fully aware of this essential difference between organized matter, such as the bodies of plants and animals, and crude mineral matter; but the distinctions between them are not rendered more evident, nor even, perhaps, much more precise, by being presented in philosophical language. Every one clearly apprehends the difference between a stone and the trunk of a tree; — that the one is the result of *growth*, the other of mere *aggregation;* that the one has been *developed*, the other *formed;* that the structure and shape of the one is due to a *peculiar internal cause*, that of the other to *external common forces;*

that the one sprang from a parent, has lived, and perhaps has died, while the other never exhibited any such phases in its existence, — never had any life to lose.

11. Of the nature of the connection between the *living principle* and the *organized structure* nothing is known. But the union being established, a self-sustaining, self-multiplying agency is the result, which may be conceived to have commenced with a single germ of each species, and from the extension and multiplication of which the actual vegetable and animal kingdoms, with their countless amount of individuals, have arisen. For organized bodies have two absolute characteristics: 1st, the power of *assimilation*, that of involving surrounding mineral matter into themselves, and converting it into their own peculiar substance, by which individuals increase in bulk, or grow; and 2d, that of *self-division* or *reproduction*, by which they increase in numbers. A single striking illustration may set both points in a strong light. The larva of the flesh-fly possesses such power of assimilation, that it will increase its own weight two hundred times in twenty-four hours; and such consequent power of reproduction, that Linnæus, perhaps, did not exaggerate, when he affirmed that "three flesh-flies would devour the carcass of a horse as quickly as would a lion."

12. The distinction between vegetables and minerals is therefore strongly marked. But the line of demarcation between plants and animals — the two classes of organized beings subject to the same general laws — is by no means so readily drawn. For the present it may suffice to state, what will hereafter be made apparent, that plants are those organized beings that live directly upon the mineral kingdom, or that grow at the immediate expense of the surrounding earth and air. They alone convert inorganic, or mineral, into organic matter. They produce organized

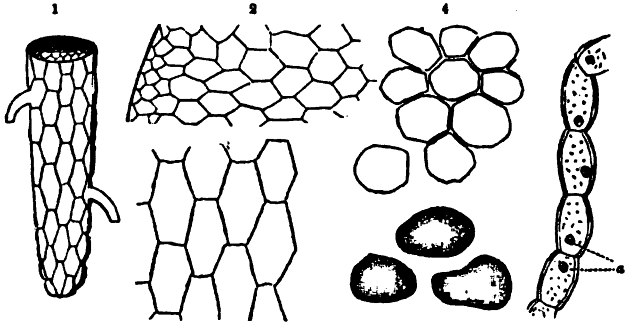
matter; while animals live upon what is thus produced. Plants, having the most intimate relations with the mineral world, are generally fixed to the earth, or other substance upon which they grow, and are nourished by mineral food, which is taken directly into their system by absorption from without, and assimilated under the influence of light in organs exposed to the atmosphere; while animals, generally endowed with locomotion, and with a high degree of sensation, have the power of selecting the food ready prepared for their nourishment, which is received into an internal reservoir, or stomach.

13. The question recurs, What is the organized fabric or tissue of plants (so different from that of minerals), which lives and grows; and how is vegetable growth effected? The stem, leaves, and fruit appear to ordinary inspection to be formed of smaller parts, and their parts of still smaller portions. Of what are these composed?

§ 2. Of the Primary, or Cellular Tissue of Plants.

14. To obtain an answer to this question, we examine, by the aid of a microscope, thin slices or sections of any of these parts, such, for example, as the young rootlet of a seedling plant. A magnified view of such a rootlet, as in Fig. 1, presents on the cross section the appearance of a net-work, the meshes of which divide the whole space into more or less regular cavities. A part of the transverse slice more highly magnified (Fig. 2) shows this structure with greater distinctness. A perpendicular slice (Fig. 3) exhibits somewhat similar meshes, showing that the pores or cavities do not run lengthwise through the whole root without interruption. In whatever direction the sections are made, the cavities are seen to be equally circumscribed, although the outlines may vary in shape. Hence, we ar-

rive at the conclusion, that the fabric, or tissue, consists of a multitude of separate cavities, with closed partitions; forming a structure not unlike a honeycomb. The cavities being called *cells*, the tissue thus constructed is termed CELLULAR TISSUE.



15. When the body is sufficiently translucent to be examined under the microscope by transmitted light, it is not necessary to make sections in this manner. We may often look directly through a delicate rootlet, (as in Fig. 1,) or the petal of a flower, and observe the closed cavities, entirely circumscribed by nearly transparent membranous walls.

16. Does this *cellular tissue* consist of an originally solid homogeneous mass, filled in some way with innumerable cavities? Or, is it composed of an aggregation of little bladders, or sacs, which, by their accumulation and mutual cohesion, make up the root or other organ? Several circumstances prove that the latter is the correct view.

FIG. 1. Portion of a young rootlet, magnified: 2 A transverse slice of the same, more magnified: 3. A vertical slice, magnified.

FIG. 4. Cellular tissue from the apple, as seen in a section: 5. Some of the detached cells from the ripe fruit; all magnified.

FIG. 6. Portion of a hair from the filament of the Spider-Lily (Tradescantia), magnified; *a*, the cytoblast.

1. The partition between two adjacent cells is double; as is seen in Fig. 4, and in most cases where the tissue is highly magnified; showing that each cell has its own special envelope. 2. This is also shown by the vacant spaces that are often observed between contiguous cells where the walls do not entirely fit together. These *intercellular spaces* are sometimes so large and numerous, that many of the cells touch each other at a few points only; as in the green pulp of leaves (Fig. 102). 3. When a portion of this pulp, or of any young and tender vegetable tissue, such as an Asparagus shoot, is boiled, the elementary cells separate, or may readily be separated by the aid of fine needles, and examined by the microscope. Fig. 103 represents two of these cells detached from the rest. 4. In pulpy fruits, &c., as in the Apple, the cells, which are at first coherent, as in ordinary cellular tissue (Fig. 4), spontaneously separate as the fruit ripens (Fig. 5).

17. The vegetable, then, is constructed of these cells or vesicles, much as a wall is built up of bricks. When the cells are separate, or do not impress each other, they are generally more or less spherical, as in Fig. 5. By mutual compression they become polyhedral. As in a mass of spheres each one is touched by twelve others, if equally pressed in every direction, the yielding cells become twelve-sided; and in a section, whether transverse (as in Fig. 2) or longitudinal (as in Fig. 3), the meshes consequently appear six-sided. If the root, or other organ, is growing in one direction more than another, the cells are commonly elongated in that direction, and become prismatic, or cylindrical when not laterally compressed. From unequal pressure or other causes, they may assume a great variety of shapes.

18. The cells vary greatly in size, not only in different plants, but in different parts of the same plant. The largest

are found in aquatics, and in such plants as the Gourd, where some of them are as much as one thirtieth of an inch in diameter. Their ordinary diameter is about the $\frac{1}{300}$ or $\frac{1}{500}$ of an inch. In the common Pink, it has been computed that more than 5,000 cells are contained in the space of half a cubic line, which is equivalent to almost 3,000,000 in a cubic inch. They are sometimes drawn out to a considerable length, as in hairs, and the fibres of cotton, which are long and attenuated cells.

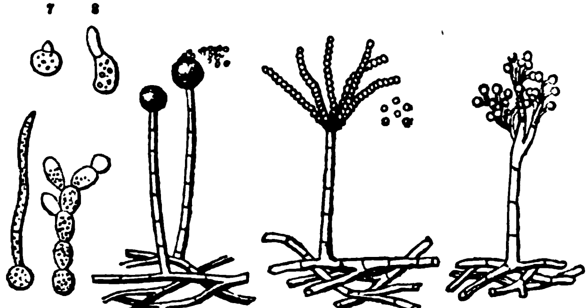
19. Some idea may be formed respecting the rate of their production, by comparing their average size in a given case with the known amount of growth. Upon a fine day in the spring, many stems shoot up at the rate of three or four inches in twenty-four hours. When the Agave or Century-plant blooms in our conservatories, its flower-stalk often grows at the rate of a foot a day; it is even said to grow with twice that rapidity in the sultry climes to which it is indigenous. In such cases new cells must be formed at the rate of several millions a day. The rapid growth of Mushrooms has become proverbial. A gigantic Puff-ball has been known to grow from an insignificant size to that of a large gourd during a single night; when the cells, of which it is entirely composed, are computed to have been developed at the rate of three or four hundred millions per hour. But it is probable that this great increase in size is in great part owing to the expansion of cells already formed.

20. As respects the mode of their production, many points still remain obscure. They are formed originally in the organizable mucilage which is contained in the older cells, or occupies the intercellular spaces. They spring, as some modern observers suppose, from the *nucleus*, or minute solid body which is often seen adhering to the walls of young cells, as in Fig. 6, *a*; and which, from its giving

birth to the cell, has been been called the *cytoblast*. Upon some part of the surface of this minute grain a slightly inflated portion, or bubble, first appears, which is compared to the crystal of a watch rising above its face; this enlarges rapidly, and acquires a much greater size than the original nucleus or cytoblast, and forms the wall or membrane of the cell. The cytoblast either disappears entirely during the growth of the cell, or remains for some time as a spot or opacity, as is readily seen with a moderate magnifying power on the cells of which the hairs that fringe the stamens of the Tradescantia, or Spider-Lily, are composed (Fig. 6). When new cells are thus formed within a mother-cell, the latter is at length ruptured or absorbed.

21. But cells once formed have the power of producing others, either by a kind of budding (*gemmiparous* reproduction), or by spontaneous fission (*fissiparous* reproduction). In the latter mode, the walls of the cell contract in the middle, so as to divide the cavity into two parts, which separate and repeat the process of division, thus forming four or more cells of one. This takes place in the formation of the pollen of Flowering Plants (51), and of the representatives of seeds in all Flowerless or Cryptogamous Plants (52). Another mode of the division of a single cell into two or more, which is probably of almost universal occurrence, may be most easily observed in the green Confervas of streams and pools, and other aquatic plants of low organization. A cell prolonged into a tube is first divided by a transverse partition; one of these joints, after elongating from its apex, has its cavity likewise divided into two by a transverse partition; the lowest of these remaining stationary, the upper elongates and continues the same process; which may thus go on indefinitely. Fig. 9 shows this mode of growth, as seen in one of those microscopic Algæ which develope in fermenting infusions.

This passes insensibly into the gemmiparous mode, where the new cell buds or sprouts, as it were, from some point of the old one, as in Fig. 7, 8, 10, and gives rise in turn to a similar progeny.

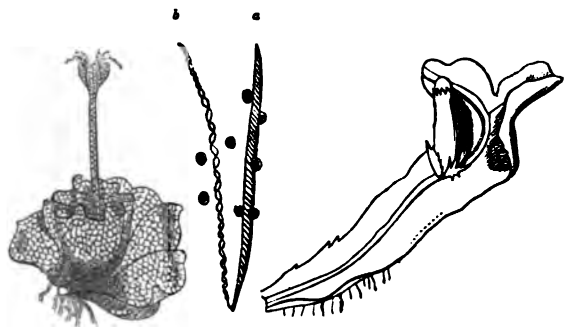


22. The lowest and simplest plants consist merely of a series of such cells placed end to end, or otherwise, as in Fig. 10. In their early and most reduced state they consist even of a single cell or vesicle, capable of producing others by budding (Fig. 7, 8), or of originating new ones in their interior, which, multiplying by spontaneous fission (21), form the representatives of seeds. The most reduced forms of vegetation do not rise above this minimum condition. Others, such as the Moulds and Mildews, or Blights (Fig. 11, 12, 13), are made up of a simple or branching series of cells, united end to end, and finally terminated by the cells which bear the so-called seeds. A large number of cells united often in a single plane form the leaves of

FIG. 7-10. The minute Alga, or infusory plant which developes in yeast and fluids which are in vinous fermentation. 7. The original vesicle or cell, which is forming a second by a kind of budding. 8. The same, farther advanced. 10. The plant fully developed by the successive production of new cells in this manner. 9. The same, or a similar plant, developing in a slightly different mode. All the figures are magnified.

FIG. 11-13. Different kinds of Mould or Mildew (minute Fungi) magnified.

Mosses, and the leaf-like expansions of the Liverworts (Fig. 14, 15), the delicate Sea-weeds, &c. Or, built up in a solid mass, they constitute the stems of Mosses, Liverworts (Fig. 14), and all such humble plants; as well as the stems and roots of all common plants in their earliest state.



23. The primitive membrane of cellular tissue is simple, uniform, and of extreme tenuity. It often remains in this condition. But it is frequently thickened and strengthened by the subsequent deposition of more solid matter upon the inner surface of the walls of the cells; to which it sometimes forms a mere lining, and sometimes a series of regular layers. In many cases, this incrusting matter accumulates so as nearly to fill the cell; as is seen in the stone of the plum, &c., which in this manner acquires its hardness. The gritty tissue of the pear consists of cells which are thus filled up (Fig. 24); and a portion of the cells of the pulp of the cranberry and whortleberry (Fig. 25) finely exhibits this unequal incrustation.

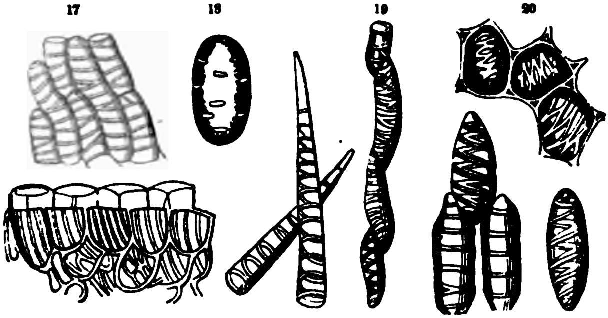
FIG. 14. Fruit-stalk, with a portion of the foliage, of a Jungermannia, magnified, to show its entire cellular structure.

FIG. 15. Jungermannia Lyellii, less than the natural size.

FIG. 16. One of the tubular spirally-marked cells from the fruit of a Jungermannia (a); and (b) the spiral coil which results from its disruption.

24. Sometimes the deposition occurs in the form of dots or minute patches, as in the tissue of the pith of the Elder (Fig. 18); or of bands, which appear in the form of rings, or of a spiral fibre adhering to the walls of the cell, as in the elongated cells that form the hairy covering of many seeds (Fig. 22), in the tissue of the Peat Moss (Fig. 17), &c. The figures 19, 20, exhibit other cases of the kind,

17 18 19 20



23 22 21

presented by species of Cactus; where the adhering bands sometimes branch (Fig. 19), or anastomose and form a net-work (Fig. 20): some of them acquire a great thickness, and form a series of disks or plates perforated in the centre, or a spiral coil projecting into the cavity of the cell in the manner of a spiral staircase (Fig. 21).

25. The thin walls of the cells sometimes give way, while the firmer bands or fibrous markings remain; as in the tissue that lines the anther (Fig. 23); the economy of

FIG. 17. Cells of the leaf of Sphagnum, or Peat Moss, marked with a spiral fibre. 18. Cell of the pith of Elder, marked with dots.

FIG. 19, 20, 21. Cells from species of Cactus, after Schleiden.

FIG. 22. Hairs from the seed-coat of Ruellia strepens; one with a spiral band, the other with a set of rings developed on the inner surface of the tube.

FIG. 23. Tissue from the lining of the anther of Cobæa scandens; where, the delicate walls of the cells being soon obliterated, the fibrous bands with which they were marked remain.

which will be explained in another place. In a similar manner the spirally-marked tubes that are mingled with the seeds of the Hepatic Mosses (Fig. 16, *a*) are converted into elastic spiral threads (Fig. 16, *b*). So, also, the delicate cells or hairs that invest the coat of numerous seeds, &c., which contain a spirally-coiled thread, give way when moistened, or are torn asunder by the elastic force with which the thread uncoils.

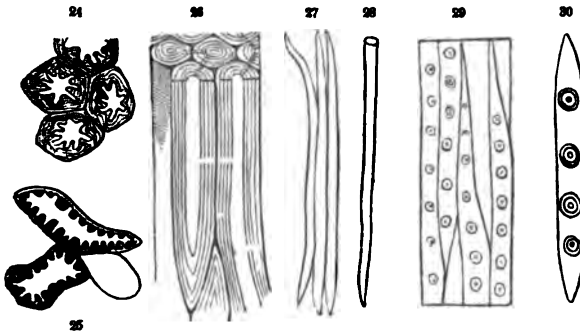
26. Common cellular tissue, such as that which forms the pith of stems, the outer bark, and the green pulp of leaves, is often called *parenchyma.*

§ 3. Of Woody Tissue.

27. It has been already stated, that Mosses and all the lowest forms of plants are made up of cellular tissue exclusively. But a plant which is to rise much above the surface, such as the stem of an ordinary herb or shrub, would not possess sufficient strength or toughness, if entirely composed of the tissue we have described. Accordingly, in all vegetables of highest organization another kind of tissue is introduced, which is mingled with the cellular in quantity varying with the degree of firmness and tenacity required. It enters somewhat sparingly into the composition of the weaker herbs, but very largely into that of shrubs and trees. Hence, as it makes up the principal part of wood, it is called Woody Tissue, or, from its fibrous form, Woody Fibre.

28. Woody tissue, however, does not consist of mere fibres, but of closed cells, drawn out, as it were, into tubes of more or less tenuity (Fig. 27, 28). Its structure is the same with that of cellular tissue, which frequently assumes the form of slender tubes, as in *cotton;* although the walls of the woody tubes are generally thicker and tougher.

Their thickness, also, commonly increases with age, by the deposition of incrusting matter, in the manner already described (23), which often accumulates until the calibre is nearly obliterated; as is shown in Fig. 26 and Fig. 97.



To this cause the difference between the *sap-wood* and *heart-wood* of trees is chiefly owing. In woody, as well as in cellular tissue, the thickening often takes place unevenly, so as to present markings of thinner or thicker portions in the form of dots, rounded spots, &c. The peculiar woody tissue of the Pine and all Coniferous trees is always marked in this way, as in Fig. 29, 30.

29. Woody tissue not only forms the principal part of wood, but abounds in the inner bark, where it is usually more tough and flexible, and therefore better adapted for cordage, cloth, &c. Thus, linen, for example, is made

FIG. 24. Magnified section of the gritty cells of the pear; the cavity almost filled with incrusting matter. 25. Similar cells from the pulp of the whortleberry.

FIG. 26. Longitudinal and transverse section of some tubes of wood, the calibre of which is nearly obliterated by the deposition of incrusting matter; highly magnified.

FIG. 27. Woody tissue from the bark of Dirca palustris, magnified; and 28, a separate fibre cut across to show that it is hollow.

FIG. 29. Piece of a Pine-shaving, magnified, to show the dots or disks which appear on the fibres of all Coniferous wood. 30. A separate woody tube or fibre of the above, more strongly magnified.

from the woody fibres of the bark of Flax, &c. It also abounds in leaves; the frame-work or fibrous skeleton of which, that gives the leaf the requisite firmness, is chiefly woody tissue. The toughness of the tubes of woody tissue, the manner in which they are closely applied side by side, their tapering ends usually overlapping each other, and the mode in which the compound fibres or cords run lengthwise through the stem or other organ, all conspire to strengthen the parts they abound in.

30. Woody tissue is evidently a mere modification of the cellular, into which it may be traced by insensible gradations.

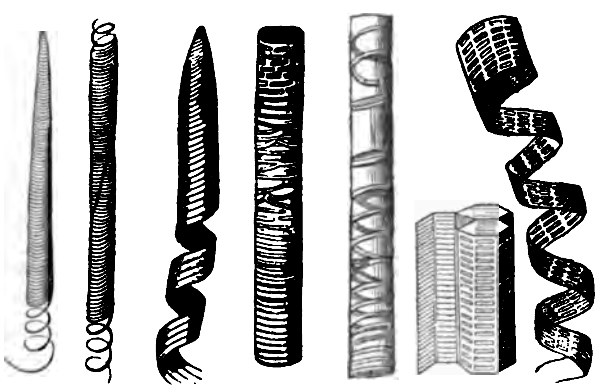
§ 4. Of Vascular Tissue, or Vessels.

31. There are still other modifications of vegetable tissue, which enter, in one or more of their forms, into the composition of all plants of higher organization (all above the Mosses), and which may be comprised under the general term of Vascular Tissue, or Vessels. They are, doubtless, all modifications of the primary universal cellular tissue. If any part whatever of any vegetable be examined microscopically in the earliest state, the ordinary cellular tissue alone is found. The other kinds appear at a later period, when some of the nascent cells elongate into tubes, and form either proper woody fibre or vessels.

32. Spiral Vessels (Fig. 31 – 33, and Fig. 94, *b*), which are usually taken as the type of vascular tissue, are tubes of variable length, with delicate walls, to the inside of which a spirally-coiled fibre is adherent. The fibre uncoils elastically when the vessel is pulled asunder. In their unrolled state they are readily examined by breaking almost any young shoot or leaf-stalk, and gently separating the extremities, when the uncoiled fibres appear to the naked

eye like a fine cobweb. In stems furnished with pith, the spiral vessels usually occupy a circle immediately around it: thence they proceed to the veins of the leaves, and of all parts which are modifications of leaves. More commonly the spire is formed of a single fibre, as in Fig. 31, 32: it rarely consists of two fibres; but not uncommonly of a considerable number, forming a band as in Fig. 33. The turns of the coil, although generally in contact, are sometimes even widely separated. The relation of the spiral vessels to the cell is evident on comparison with those cells in which the walls are marked with spiral lines or threads, as in Fig. 16, 17, 19, 22, and especially with those cases where the thread uncoils elastically.

33. Ducts (Fig. 34–37) differ from spiral vessels in the



31 32 33 34 35 36 37

FIG. 31. A simple spiral vessel, torn across, with the thread uncoiling. 32. Two such vessels cohering at their extremities.

FIG. 33. A compound spiral vessel, partially uncoiled, from the Banana.

FIG 34. A portion of a duct from the leaf-stalk of Celery; the lower part *annular*; the middle *reticulated*, and the thread at the upper part broken up into short pieces.

FIG. 35. Duct from the Wild Balsam or Jewel-weed; the coils of the thread distant; a portion forming separate rings.

FIG. 36. Scalariform ducts of a Fern, rendered prismatic by mutual pressure.

FIG 37. Duct of a Fern, torn into a spiral band.

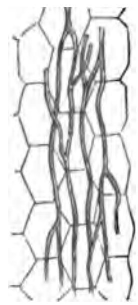
thread being incapable of unrolling, and usually broken into short coils, or into separate rings (*annular ducts*, as in the lower part of Fig. 34 and Fig. 94, *e*), or into irregular bands which sometimes unite with each other (*reticulated ducts*, Fig. 34, upper part). Occasionally nearly all these varieties may be observed in different portions of the very same vessel; as in the figure last referred to, taken from the Celery, and Fig. 35, from the Wild Balsam. Ducts are usually much larger than spiral vessels. They occur abundantly among the woody tissue of almost all plants. By mutual pressure, the tube is often rendered prismatic; and the fibre appearing in the form of transverse bars, resembling the rounds of a ladder, the vessels thus formed have been termed *scalariform ducts*. These abound in Ferns, from a species of which the illustration (Fig. 36) is taken. The Ferns and their allies also exhibit another kind of duct, the membrane of which may itself be torn into a spiral band, following the direction of the thread or bars; as in Fig. 37. This is perhaps a metamorphosis of the compound spiral vessel, Fig. 33.

34. Dotted Ducts, called also Pitted or Vasiform Tissue (Fig. 38, 39), are of greater calibre than any other kind of vessel. The pores so conspicuous to the naked eye on the cross section of many kinds of wood, such as the Oak, Chestnut, Mahogany, &c., are the large open orifices of these vessels (Fig. 94, *d*). Their walls are marked with round or oblong dots, instead of threads or fibres. Sometimes they are continuous tubes of considerable length (Fig. 39); but commonly, the circular lines which they exhibit at short intervals (as in Fig. 38), and the imperfect transverse partition which is often found at these points, plainly indicate their composition; showing that they are made up of a series of cells placed end to end, with the intervening partitions more or less obliterated. An exami-

nation in the forming state confirms this view; and in the young stems of herbaceous plants, they may often be separated artificially into their primitive elements. These jointed ducts sometimes exhibit ramifications; so as to explain the nature of the following kind of tissue.


38


39


40


41

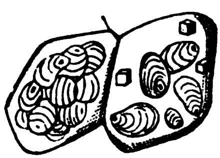
35. The VESSELS OF THE LATEX or milky juice (Fig. 40, 41), the only remaining kind of vessel, are especially distinguished by this disposition to ramify. They even *anastomose*, or form a kind of net-work by the union of their branches, like the veins of animals, so that there is a free communication throughout the whole system. The articulations which they often present (as in the upper part of Fig. 41), seem to prove that they are formed by the confluence of cylindrical cells. They are of extreme tenuity, their average diameter being less than the fourteen-hundredth of an inch. The old trunks, when gorged, are often much larger than this; but in an earlier state they are so delicate, that they are only to be discovered with the aid of the most powerful microscopes. They contain the milky and other peculiar juices of plants.

FIG. 38, 39. Dotted ducts from the Vine.

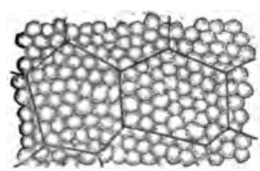
FIG. 40. Vessels of the latex, ramifying among cellular tissue, in the Dandelion; and 41, older and larger vessels from the same plant; all highly magnified.

§ 5. Of the Contents of the Tissues.

36. The cells and vessels contain the sap and various juices of plants; the nature of which will be better apprehended hereafter. Their most important solid contents are, 1st, the Chromule or Chlorophylle, which gives the green color to the leaves and herbage. It consists of minute grains, which lie loose in the cells of Parenchyma (Fig. 103), and is formed only in parts that are exposed to light; and 2d, Starch. This important vegetable product is composed of oval or rounded grains, which are accumulated in the cells, and which under a microscope exhibit a regular structure. Each grain is made up of numerous layers of solid matter, deposited concentrically around a point or nucleus, which is usually very eccentric. Their appearance is shown in the subjoined figures.



42



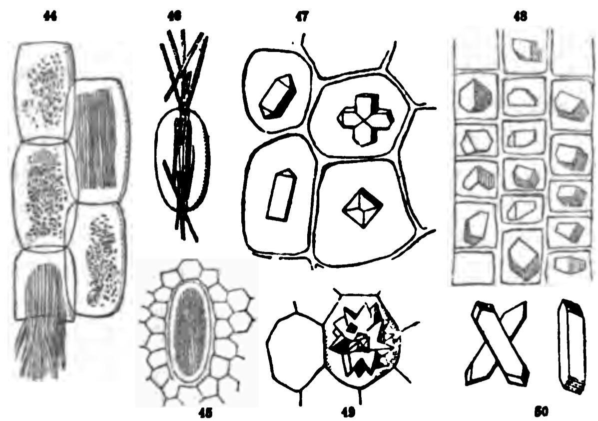
43

37. The cells, besides, often contain minute crystals of various mineral substances, (commonly oxalate of lime,) which are known by the name of Raphides. The name (which is merely the Greek word for needles) was originally applied to the acicular or needle-shaped crystals which abound in many plants; as in the stalk of the Rhubarb (Fig. 44), and of the species of the Arum family (Fig. 45, 46); but it is now indiscriminately applied to all crystals which

FIG. 42. Two cells of a potato, with the starch-grains they contain, highly magnified; one of the cells contains a few crystals also.

FIG. 43. A minute portion of Indian meal, strongly magnified; the cells absolutely filled with grains of starch.

are found in the tissue of vegetables. In the common Arum or Indian Turnip, as well as in the Calla Æthiopica and all other plants of that family, the crystal-bearing cells (Fig. 45) may readily be detached from the rest of the tissue; and when moistened, they forcibly discharge their contents, in a curious manner, from an orifice at each end, as is shown in Fig. 46. When the crystals occur in other forms,



there is commonly either a single one in each cell, as in Fig. 47, 48, or a single mass or group, as in Fig. 49. In the potato, several minute cubes are found in each cell, scattered among the starch-grains (Fig. 42). The number of these crystals is often astonishing. In the thin inner layers of the bark of the Locust, for example, every cell

FIG. 44. Raphides, or acicular crystals, from the stalk of the Rhubarb: three of the cells contain starch or chlorophylle; and two of them raphides.

FIG. 45. Raphides of an Arum, contained in a large cell; and 46, the same detached from the surrounding tissue, and discharging its contents upon the application of water.

FIG. 47. Crystals from the Onion; one of them a hemitrope.

FIG. 48. Crystals of the inner bark of the Locust.

FIG. 49. A glomerate mass of crystals from the Beet-root.

FIG. 50. Crystals from the bark of Hickory. This, and the Figures 42, 46, 47, and 48, are from sketches kindly supplied by Professor Bailey of West Point.

contains a crystal, as is seen in Fig. 48. And Professor Bailey, who has devoted particular attention to this subject, has recently computed, that in a square inch of a piece of Locust-bark, no thicker than ordinary writing paper, there are more than a million and a half of these crystals.

§ 6. Of the Epidermis and its Appendages.

38. The whole surface of the plant, exposed to the air, is covered with a skin, or Epidermis, which consists of one or more of the outer layers of cellular tissue, with the vesicles in a state of firm cohesion, and containing no chlorophylle (36). There is, however, no distinct epidermis in the lowest forms of vegetables, nor generally in those parts that grow under water. (The nature of what has been specially termed the *cuticle* is explained at 140, note.)

39. Hairs are prolongations of cells of the epidermis, consisting either of single elongated cells, or of several cells placed end to end (as in Fig. 6), or of various combinations of such cells. *Glandular hairs* bear at their apex a cellular apparatus, for the elaboration of peculiar secretions, such as the fragrant volatile oil of the Sweet Brier, and the acid colorless fluid of the Nettle. They are often called *glands*, especially when not raised on a stalk.

40. Prickles are larger and indurated processes of the epidermis.

41. Stomates, or Stomata, or *breathing-pores*, are peculiar orifices in the epidermis of the leaves and other green parts of plants, the structure and office of which will be elsewhere described (142).

CHAPTER II.

OF THE COMPOUND ORGANS OF PLANTS IN GENERAL.

42. The vegetable fabric is entirely constructed of the elementary materials which have now been briefly described. The *cells*, *fibres*, and *vessels*, by their aggregation, make up the root, stem, leaves, &c.; which have accordingly been termed the Compound Organs of plants.

43. We obtain the clearest conception of the plant as a whole, and of its mode of growth, by tracing an individual vegetable from the *embryo* state (that in which it exists in the seed) throughout the successive stages of its development. The plant, then, in the early, rudimentary state at which we commence its history, is an *embryo* (Fig. 52) contained in the seed (Fig. 51). The form of this initial plantlet varies greatly in different species. It is often an oblong or cylindrical body, simple at one extremity, and nicked or lobed at the other, as in the case we have chosen for illustration. Upon this apparently so simple, and often minute body, all the laws of vegetable life are impressed; and its first effort, when it grows, or *germinates*, is to give expression to the most universal of these laws. The two extremities of the embryo are differently affected by the same external agents, and exhibit exactly opposite tendencies. The one end is potentially *stem*; the other, *root*. As soon as it begins to grow, it lengthens at both ends: the one extremity, avoiding the light and seeking to bury itself in the soil, lengthens in the direction of the earth's centre; this forms the *root*: the other assumes exactly the contrary direction, as if it sought the light and air, and rising upwards forms the *stem*. This tendency of the germinating plant to elevate one portion into the air, while it buries the

other in the soil, is absolute and irreversible. If obstacles intervene, the root will take as nearly a downward, and the stem as nearly an upward, direction as possible. It is only the first manifestation of an inherent property which continues, with only incidental modifications, throughout the whole growth of the plant, although, like instinct in animals, it is strongest at the commencement: and it insures that each part of the plant shall, at its development, be placed in the situation most suitable to its existence; that is to say, the root in the earth, and the stem and leaves in the air.

51

52 53 54 55 56

44. The plant, then, possesses a kind of polarity; it is composed of two counterpart systems, namely, a *descending axis* or root, and an *ascending axis* or stem. The point of union of the two is termed the *crown*, *neck*, or *collar*. Both the root and stem branch; but the branches are repetitions of the axis from which they spring, and obey its laws. The

FIG. 51. A longitudinal section of a seed, showing the embryo or rudimentary plant it contains. 52. The embryo taken from the seed, and its rudimentary leaves, or cotyledons, a little separated. 53. The same in germination, the cotyledons expanding into the first pair of leaves. 54, 55, 56. The seedling plant more advanced.

branches of the root tend to descend; those of the stem tend to ascend. There is a difference, however, between the branches of the stem and those of the root. The latter are given off in no particular order; while those of the stem are produced at definite points, and with a predetermined arrangement.

45. The root bears nothing but naked branches, mere subdivisions of the descending axis. But that extremity of the embryo which gives birth to the stem is furnished with other rudimentary organs,—to be developed as it developes. It is from the first a *bud*, that is, a growing point or undeveloped axis, covered with the rudiments of leaves. As the bud developes, and the stem lengthens, the leaves successively expand in regular order. The first leaf, or the first pair of leaves, generally exists in the embryo, either in a rudimentary condition, as in Fig. 51, or more or less enlarged and thickened by the accumulation of nourishing matter in their tissue, as in the Almond, the Bean, &c., where they form the principal bulk of the embryo; or else they are foliaceous, and even green in color, from the first, as in the Barberry, the common Morning-glory, or Convolvulus, and the Linden. These primary leaves are termed *cotyledons*, or *seed-leaves*. Occasionally some of the succeeding leaves of the rudimentary stem are visible in the embryo, as in the Almond, much as in an ordinary bud.

46. When the stem branches, it is by the production of other buds, which in their turn implicitly follow the same mode of development.

47. The *root*, *stem*, and *leaves*, then, preëxist in the embryo, in a more or less rudimentary condition. Of these, plants essentially consist; for they are all that are requisite to, and actually concerned in, their life and growth. Indeed, the whole ulterior evolution of the plant exhibits only repetitions of these essential parts, under more or less

varied forms. They are, therefore, properly termed the FUNDAMENTAL ORGANS of plants, or the ORGANS OF VEGETATION.

48. The root absorbs the crude food of the plant from the soil; this is conducted through the stem into the leaves, is in them digested, under the agency of solar light and heat; and the nourishment thus prepared is returned into the stem and root, to be expended in the formation of new rootlets, new branches, and new leaves. Thus, the more the plant grows, the more it multiplies its instruments and means of growth; and its growth would seem to be limited only by the failure of food, by the want of a fit temperature, or by other accidents.

49. Sooner or later, however, a new feature appears; the plant changes its mode of development, and bears *flowers.* The influence which flowering exerts upon the plant may best be considered after the phenomena of vegetation are duly explained. But the final end of the flower is the production of a seed, containing an embryo-plant which is composed of these same fundamental organs, and which in its development repeats these successive steps, to attain the same ultimate result.

50. Plants are doubtless all constructed upon this one general plan; and their development appears to follow a few simple laws, which, clearly apprehended and kept in mind, afford a ready and consistent explanation of the manifold diversities which the vegetable kingdom exhibits. The pleasing and almost infinite variety which it displays results from successive modifications in the details, and from circumstantial, although by no means casual, variations in the carrying out of a universal scheme.

51. It must be remarked, that ordinary herbs, trees, &c., in other words, plants of the highest organization, are here assumed as exhibiting the typical plan of vegetation.

But this plan will be found to be greatly modified, and in most respects simplified, as we descend towards the confines of the vegetable kingdom. Before the tribe of Ferns is reached, proper flowers disappear, and consequently seeds containing a ready-formed embryo-plant within them are no longer found. The Mosses, and all below them in the series, are composed of simple cellular tissue (22, 27) alone. In some Hepatic Mosses (Fig. 15), and in the Lichens, Fungi, and Algæ, or Sea-weeds, the marked distinction between the stem and leaves is entirely lost; these two organs being confounded or confluent into one, which performs the offices of both. And even the distinction between root and stem eventually disappears, as in those Lichens which present a flat, expanded crust, and adhere to rocks or the trunk of trees by the whole lower surface, which answers to *root*, while the upper surface, presented to the light, fulfils the office of *leaf.* In other words, the type of vegetation, obscurely shadowed forth in its most reduced form by the Fungi, Lichens, and Sea-weeds, but more plainly sketched in the Mosses and Ferns, is completely realized in the *higher* or *Flowering* Plants.

52. For the sake of greater simplicity and clearness, we shall, for the present, leave these lower or Flowerless Plants entirely out of view, and explain the phenomena of vegetation, as manifested in the higher or Flowering Plants; as if they were the only, as they are in fact the most perfect, representatives of the vegetable world. The peculiarities of the different tribes of Flowerless Plants may afterwards be separately noticed.

CHAPTER III.

OF THE DESCENDING AXIS, OR ROOT.

§ 1. Its Structure, Growth, and Offices.

53. The Organs of Vegetation (47) in Flowering Plants, namely, the root, stem, and leaves, are to be considered in succession, commencing with the root, which, being charged with the very earliest office, that of absorbing the plant's food from the soil, is one of the parts which is earliest formed.

54. The definition of the root has already been given (43, 44). It is the descending axis, or that portion of the trunk which, avoiding the light, grows downwards, fixing the plant to the soil, and absorbing nourishment from it. It differs from the stem, not only in the direction of its growth, but in giving off branches without order, in being entirely destitute of leaves or other appendages, of joints, and also of buds (except that it has the power of producing the latter, under circumstances hereafter to be mentioned); its epidermis is destitute of stomates (41) or breathing pores; and, in the greater portion of plants, it has no pith. Another peculiarity in its mode of growth is worthy of especial notice. Roots increase in length entirely, or chiefly, by the addition of new matter to their lower extremities or points, extending very much in the same way as an icicle; except that the new matter, constantly deposited in layer over layer upon its youngest extremity, is supplied from within, and not from without. Consequently the growing points of roots consist of newly formed and very delicate tissue, which is extremely hygrometrical, and absorbs with great avidity the fluid presented by the soil. It is by these ex-

tremities, called *spongioles* or *spongelets*, that absorption by the root almost exclusively takes place, and the vast quantity of fluid supplied which is exhaled from the leaves during vigorous vegetation. Hence the danger of disturbing the roots during the season of active growth. In the spring, when the sap is rapidly consumed by the fresh leaves, the rootlets are also in rapid action. The growth of the branches and roots being simultaneous, while new branchlets and leaves are developing, the rootlets are extending at a corresponding rate, and their tender absorbing points are most frequently renewed. But towards the close of summer, as the leaves grow languid and the growth of the season is attained, the rootlets also cease to grow, the loose tissue of the spóngelet, not being renewed, gradually solidifies, and its functions at length nearly cease. This indicates the proper period for transplantation, namely, in the autumn after vegetation is suspended, or in early spring before it recommences.

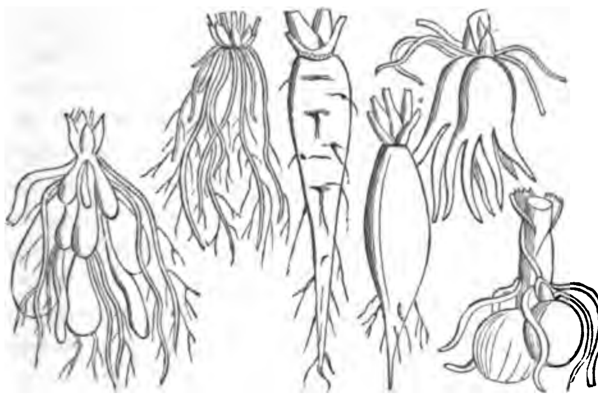
55. The elongation of roots by their advancing points alone is admirably adapted to the conditions in which they are placed. Growing as they do in a medium of such unequal resistance as the soil, if roots increased like young stems, by the elongation of the whole body, they would be thrown, whenever the elongating force was insufficient to overcome the resistance, into knotted or contorted shapes, very ill adapted for the free transmission of fluid. But, lengthening only at their extremities, they insinuate themselves with great facility into the crevices or yielding parts of the soil, and afterwards by their expansion in diameter enlarge the cavity; or, when arrested by insuperable obstacles, their advancing points follow the surface of the opposing body until they reach a softer medium. In this manner they extend from place to place, as the nourishment in their immediate vicinity is consumed. Hence, also, may be derived a

simple explanation of the fact, that roots extend most rapidly and widely in the direction of the most favorable soil, without supposing any prescience on the part of the vegetable, as some have imagined.

56. Although roots are not naturally furnished with buds, like the stem, yet, under certain circumstances, those of many trees and shrubs have the power of producing them irregularly. Thus, when the trunk of a young Apple-tree or Poplar is cut off near the ground, while the roots are vigorous and full of sap, those which spread just beneath the surface produce buds, and give rise to a multitude of young shoots. The roots of the Maclura, or Osage Orange, habitually give rise to buds and branches. Such buds are said to be irregular, or *adventitious*.

57. Besides the general office of roots, that of absorbing the crude food of the plant from the soil, they also frequently serve as reservoirs of nourishment stored up for future use. The crude sap or fluid which plants imbibe from the soil is not, as such, employed in growth. In this lies an essential difference between plants and animals. While the latter live on organic food (12) already prepared for their nourishment, plants take in mineral matter, — mere earth, air, and water, — and first, by the most important process in animate nature (since upon it every thing else depends), convert it into organic matter, in the form of mucilage, starch, sugar, &c. This prepared nourishment is alone employed in growth. Now in an *annual* plant (which springs from the seed, flowers, and dies the same year), the whole of this food, as fast as it is elaborated, is expended in the production of new branches, leaves, and at length of flowers. The latter, as well as the fruit, exhaust the plant greatly (in a manner hereafter to be explained (240 – 243)), and having no accumulated stock to sustain this draught, the plant inevitably perishes. Such

(annual) plants always have branching *fibrous* roots (as in Mustard, Barley, Fig. 56^2, &c.), well adapted for absorption from the soil, but for that alone.



58. But other plants have the power of accumulating in their tissues a large portion of this elaborated food, for future use. This is the case with *biennial* plants, such as the Radish, Carrot, Beet, and Turnip, which do not flower the first season, nor even expend in the production of stems and branches much of the nourishment they generate; but, forming a large tuft of leaves at the very surface of the ground, they accumulate in the root nearly the whole summer's supply of nourishment. Such thickened roots are said to be *fleshy*, and receive different names according to the shapes they assume. When the accumulation takes place in the main trunk or tap-root, it becomes *conical*, as in the Carrot, Fig. 57, when it tapers regularly from the base or crown to the apex; it is *fusiform* or *spindle-shaped* when it tapers upwards as well as downwards, as in the Radish, Fig. 61; or *napiform* or *turnip-shaped*, when

FIG. 56^2–62. Different kinds of roots.

much swollen at the base, so as to become broader than long. If some of the branches or fibres are thickened, instead of the main axis, the root is said to be *fasciculated* or clustered, as in Fig. 59; or *tuberiferous* or *tuberous*, when they assume the form of rounded knobs, as in Fig. 62; or *palmate*, when the knobs are branched, as in Fig. 58. These must not be confounded with tubers, such as potatoes, which are forms of stems. When vegetation is resumed the following spring, these plants, such as the Carrot, Beet, &c., make a remarkably vigorous and rapid growth, shooting forth a large stem, and bearing flowers, fruit, and seed, almost wholly at the expense of the accumulation of the previous year; this store is soon consumed, therefore; and the plant, meanwhile neglecting to form new roots, perishes from exhaustion. This is the economy of *biennial* herbs.

59. A third class of herbs do not so absolutely depend upon the stock of the previous season, but annually produce new roots and form new accumulations; so that, while one reservoir is utterly exhausted in flowering, &c., a new stock is meanwhile providently secured for the next year's sustenance; and so on from year to year. Hence, although a portion annually perishes, yet the individual plant survives indefinitely. Such are *perennial* herbs; among which this economy may be studied in the Orchis (Fig. 58, 62), the Dahlia, &c. In woody plants, the accumulation is distributed throughout the whole stem as well as the root; and the flower-stalks, &c., only perish after flowering and the ripening of the fruit.

§ 2. Its Aerial and Parasitic Modifications.

60. Thus far, the primitive root, that which originated in germination, has alone been considered. But roots may

also spring from any portion of a growing stem; and, when formed, they follow the ordinary course, avoiding the light and seeking to bury themselves in the soil. Most creeping plants produce them at every joint; and branches, when bent to the ground and covered with earth, will commonly strike root. So, often, will separate pieces of young stems, if due care be taken; as when plants are propagated by cuttings. As to the causes which induce the stem to emit roots, we only know that darkness and moisture are generally necessary. Hence stems do not usually strike root, except when in contact with the ground. To this, however, there are various exceptions, which may be classified as follows.

61. (1st.) The case of plants which climb by rootlets, like the Ivy, our own Poison Ivy (Rhus Toxicodendron), and the Bignonia or Trumpet-Creeper, which in this way reach the summit of high trees. Such plants derive their nourishment from their ordinary roots imbedded in the soil; their copious aerial rootlets merely serving for mechanical support.

62. (2d.) The case of true *aerial* roots, which, emitted from the stem in the open air, descend to the ground and establish themselves in the soil. This may be observed, on a small scale, in the stems of Indian Corn, where the lower joints often produce roots which grow to the length of several inches before they reach the soil. But more striking cases of the kind abound in tropical regions, where the sultry air, saturated with moisture for a large part of the year, favors the utmost luxuriance of vegetation. The Pandanus or Screw-Pine (a Palm-like tree, often cultivated in our conservatories) affords a well known instance. The strong roots, emitted in the open air from the lower part of the trunk, soon reach the soil, as is shown in Fig. 63, giving the tree the appearance of having been partially

raised out of the ground. The famous Banyan-tree (Fig. 65) affords a still more striking illustration. Here the

63 64

aerial rootlets strike from the horizontal branches of the tree, often at a great height, and swing free in the air, like pendent cords; but they finally reach and establish themselves in the ground, where they increase in diameter and form numerous accessory trunks, surrounding the original bole and supporting the wide-spread canopy of branches and foliage. Very similar is the economy of the Mangrove (Fig. 64) which inhabits muddy sea-shores throughout the tropics, and even occurs sparingly on the coast of

FIG. 63. The Pandanus, or Screw-Pine; with 64, a Mangrove-tree (Rhizophora Mangle).

Florida and Louisiana. Its aerial roots spring both from the main trunk, as in the Pandanus, and from the branchlets, as

65

in the Banyan. And besides, this tendency to shoot in the air is shown even in the embryo, which begins to germinate while the pod is yet attached to the parent branch; the radicle, or root-end of the embryo, elongating into a slender thread, which often reaches the ground from the height of many yards, before the pod is detached. In this manner the Mangrove forms those impenetrable maritime thickets which abound on low, muddy shores, within the tropics.

63. (3d.) Another modification occurs in the case of ***Air-plants***, or ***Epiphytes;*** where the roots not only strike in the free air, but throughout their life have no connection with the soil. They generally grow upon the trunks and branches of trees; their roots merely adhering to the bark to fix the plant in its position, or else hanging loose in the air, from which such plants draw all their nourishment. Of this class are a large portion of the gorgeous Orchidaceous plants of very warm and humid climes, which are so much

FIG. 65. The Banyan-tree, or Indian Fig (Ficus Indica).

prized in hot-houses, and which, in their flowers as well as their general aspect, exhibit such fantastic and infinitely varied forms. Some of the flowers resemble butterflies, or strange insects, in shape as well as in gaudy coloring; such, for example, as the Oncidium Papilio (Fig. 66), which we have selected for one of our illustrations. To another tribe

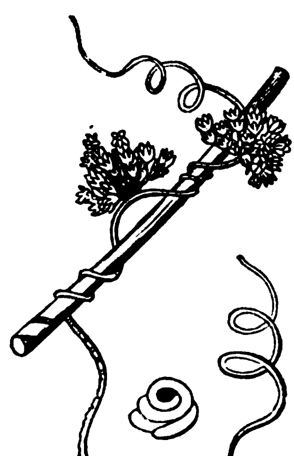
66

of Epiphytic Plants belongs the Tillandsia, or Long Moss, which, pendent in long and gray tangled clusters or festoons from the branches of the Live-Oak or Long-leaved Pine, gives such a peculiar and sombre aspect to the forests of the warmest portions of our Southern States. They are called Air-plants, in allusion to the source of their nourish-

FIG. 66. Oncidium Papilio, and Comparettia rosea; two Epiphytes of the Orchis family; showing the mode in which Air-plants grow.

ment; and Epiphytes, from their growing upon other plants, and in contradistinction to

64. (4th.) *Parasites*, or Parasitic Plants, that not only strike root upon other vegetables, but live at their expense; which Epiphytes do not. Such parasites as the Mistletoe are at no period connected with the earth; but the seed germinates upon the trunk or branch of the tree where it happens to fall, and the root penetrates the bark and young wood, just as those of ordinary plants penetrate the soil. It draws from the sap-wood (116) of the foster-plant the crude sap which that has absorbed from the soil, and digests it in its own green foliage. But those parasitic plants, which, like the Orobanche, Beech-drops, &c., strike their roots into the bark of other vegetables, and thence derive their food already elaborated, have no occasion for digestive organs of their own, and are in fact always destitute of green foliage. In some instances of the kind, as in the Dodder (Cuscuta, Fig. 67), the seeds germinate in the earth, from which the primitive root derives its nourishment in the ordinary manner; but when the slender twining stem reaches the surrounding herbage, it gives out aerial roots, which attach themselves

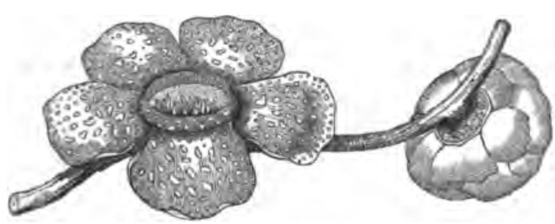


67 68 69

FIG. 67. The common Dodder of the Northern States (Cuscuta Gronovii), of the natural size, parasitic upon the stem of an herb: the uncoiled portion at the lower end shows the mode of its attachment. 68. The coiled embryo taken from the seed, moderately magnified. 69. The same in germination; the lower end elongating into a root; the upper, into a thread-like leafless stem.

firmly to the surface of the supporting plant, penetrate its epidermis, and feed upon its juices; while the original root and base of the stem perish, and the plant has no longer any connection with the soil. Being nourished by the elaborated food of another species, or stealing its nourishment ready prepared, it requires no proper digestive organs of its own, and, consequently, does not produce leaves. This economy is, as it were, foreshadowed in the embryo of the Dodder, which is a slender thread spirally coiled in the seed (Fig. 68, 69), and which presents no vestige of cotyledons or seed-leaves. A species of Dodder infests and greatly injures flax in Europe, and sometimes makes its appearance in our own flax-fields, — doubtless introduced with the imported seed. Some species make great havoc in the clover-fields of the Old World.

65. Such parasites do not live upon all plants indiscriminately, but only upon those whose elaborated juices furnish them a propitious nourishment. Their seeds, in some cases, will germinate only when in contact with the stem or root of the species upon which they are destined to live. Hav-



70

ing no need of foliage, such plants may be reduced to a stalk with a single flower or cluster of flowers, as in the different kinds of Beech-drops, Fig. 719, the Cytinus, which

FIG. 70. Rafflesia Arnoldi; an expanded flower, and a bud, directly parasitic on the stem of a vine.

is parasitic on the Cistus of the South of Europe, &c. They may even be reduced to a single flower directly parasitic on the bark of the foster-plant, without the intervention of any manifest stem. A truly wonderful instance of this kind is furnished by that vegetable Titan, the Rafflesia Arnoldi of Sumatra. This flower, which constitutes the entire plant, was discovered upon the stem of a kind of grape-vine, and, when expanded, it is nine feet in circumference! Its weight was calculated at fifteen pounds. The annexed figure represents the flower of Rafflesia Arnoldi, reduced to the scale of half an inch to a foot (Fig. 70). Its color is light orange, mottled with yellowish-white. A few other species, of less gigantic size, have also been discovered in the Eastern Archipelago.

CHAPTER IV.

OF THE ASCENDING AXIS, OR STEM.

§ 1. Its General Characteristics and Mode of Growth.

66. The stem is that portion of the trunk which grows in an opposite direction from the root, seeking the light, and exposing itself as much as possible to the air. All Flowering Plants possess stems. In those which are said to be *stemless*, it is either very short, or concealed beneath the ground. Although the stem always takes an ascending direction at the commencement of its growth, it does not uniformly retain it; but sometimes trails along the surface of the ground, or burrows beneath it, sending up branches, flower-stalks, or leaves into the air. The common idea,

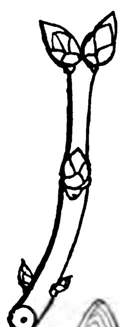
therefore, that all the subterranean portion of a plant belongs to the root, is by no means correct.

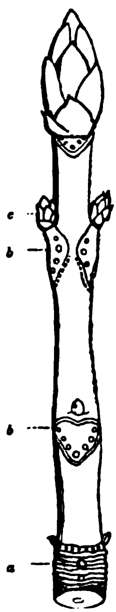
67. The root gives birth to no other organs, but itself directly performs those functions which pertain to the relations of the vegetable with the soil; — its branches bind the plant to the earth; its newly formed extremities, or fresh rootlets, imbibe nourishment from it. But the aerial functions of vegetation are chiefly carried on, not by the stem itself, but by a distinct set of organs which it bears, namely, the leaves. Hence the production of leaves is one of the characteristics of the stem. Roots do not produce them.

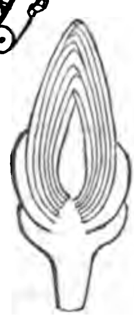
68. Even in the embryo, the stem is furnished with leaves, either in a rudimentary or a more or less developed condition (45). As the embryo stem lengthens, leaves are produced at certain regular, definite points. The undeveloped stem is, in fact, made up of a certain number of these *leaf-bearing points*, separated by short intervals; and its growth consists, primarily, in the elongation of these intervening portions (much after the mode in which the joints of a pocket-telescope are drawn out), so as to separate the leaf-bearing points to a greater or less distance from each other, and allow the leaves to expand. The *joints*, or points from which leaves arise, are called NODES; and the naked portion that intervenes between two nodes is termed an INTERNODE. Sometimes the nodes are scarcely distinguishable, except by giving rise to leaves; but often they are very evident, dividing the stem into joints (inappropriately so called, since there is no disposition to separate at these points), as in the Bamboo, Sugar-Cane, and all Grasses. They are equally evident in most young woody stems, where they are designated by the leaf-scars. One leaf may arise from each node, or two placed opposite each other, or three or more, placed in a ring (in botanical language, a *whorl* or *verticil*) around the stem. A series of these joints, or simi-

lar parts, each growing from the summit of the preceding, continues the stem upwards. The stem, which in the embryo consists of a single joint, — an internode with a node at its summit, — repeats itself by producing a second and similar one from its apex; that, by producing a third similar to the second, and so on, throughout its whole growth. The apex of the stem, then, is always crowned by an undeveloped portion, that is, a BUD.

74







72 73 71

69. This fundamental plan of the stem is beautifully exemplified in the gradual evolution of a seedling plant; where each internode developes, perhaps nearly to its full length, and expands the leaf or pair of leaves it bears, before the elongation of the succeeding one commences. The internode which preëxists in the embryo elongates in germination, and raises the seed-leaves (45) into the air; they expand and elaborate the material for the next joint,

FIG. 71. Diagram of a longitudinal section of a bud, such as that of the Horse-Chestnut.

FIG. 72. A year's growth of a Horse-Chestnut branch, crowned with a terminal bud: *a*, scars left by the bud-scales of the previous year: *b*, scars left by the fallen leaf-stalks: *c*, axillary buds.

FIG. 73. Diagram to illustrate the development of the bud in 71, 72.

FIG. 74. Branch and buds (all lateral or axillary) of the Lilac.

the leaves of which in turn prepare the material for the third, &c. (Fig. 52 – 56.) Essentially similar is the development of a stem from the ordinary bud of a shrub or tree, except that the different steps follow each other more closely. Such buds, which appear at the apex of a stem when it has completed its growth for the season, often exhibit the whole plan and amount of the next year's growth; the nodes, and even the leaves they bear, being already formed, and only requiring the elongation of the internodes for their full expansion. The structure is shown in the annexed diagram (Fig. 71), which represents the vertical section of a bud (like that which crowns the stem in Fig. 72), as it appears in early spring. The dry, closely packed scales which envelope it are the representatives of the last leaves of the preceding year, which, in this peculiar form, serve for protection from the effects of moisture and sudden changes of temperature during the dormant state.* As the bud is supplied by the stem on which it rests with nourishment sufficient for its whole development, it elongates rapidly; and although the growth commences with the lowest internode, and follows the same course as in the seedling, yet the second, third, and fourth internodes, &c., have begun to lengthen long before the first has attained its full growth; as is attempted to be shown by the diagram, Fig. 73. As the stem is developed from a bud, so, at the close of the season, if it survive, it is again terminated with a similar one, which repeats the same process.

* That the bud-scales are of the nature of leaves will appear very evident to one who attentively observes the expanding buds of the Horse-Chestnut, the Lilac, &c., and marks the gradual transition of these scales into the ordinary leaves of the young branch. Indeed, in several of the common Honeysuckles (Lonicera) the bud-scales are nearly all green and herbaceous, — mere abbreviated leaves.

70. In this manner the stem increases in length from year to year. Such a stem would of course remain simple and unbranched; as is the case with many during the first year, and with others, such as most Palms (Fig. 98[a]) and Reeds throughout their whole existence.* But more commonly branches appear, even during the first year's growth. Their production may now be considered.

§ 2. Its Ramification and Multiplication.

71. Besides the *terminal* bud, that continues the main stem, each node produces one or more additional ones. These correspond to the leaves which the node bears, both in situation and number. They regularly appear, or at least may appear, one in the *axil* of each leaf, that is, in the upper angle which the leaf forms with the stem. (See Fig. 72, *c*, where the point at which the fallen leaves were attached is marked by the broad scar, *b*, just below the bud.) Hence these *lateral* buds are also said to be *axillary*. If they do not always actually exist in every axil, yet they may appear, and are habitually developed there, under favorable circumstances.

72. These *lateral* or *axillary buds* are new axes of growth: when they grow, they give rise to *branches;* which are repetitions, as it were, of the main stem, growing just as that did from the seed; excepting merely, that, while that was implanted in the ground, these are implanted on the parent stem. The branches thus produced are in turn provided with similar buds in the axils of their leaves, which enjoy

---

* In most of our trees, the yearly growth is shown by an assemblage of scars or rings (Fig. 72, *a*), which mark the attachment of the bud-scales. The reason why these, as well as the leaf-scars, are obliterated after several years, will hereafter appear.

the same relation to the primary branch that it does to the main stem, and are capable of developing into branches of a third order, and so on indefinitely, producing the whole *ramification* of the plant. The whole is merely a series of repetitions, from new starting-points, of what took place in the evolution of the first axis, preëxistent in the seed. In the seed, therefore, or rather in the *embryo* it contains, we have the expression, in a condensed form, of the whole being of the plant.

73. The arrangement of axillary buds depends upon that of the leaves. When the leaves are *opposite* (that is two on each node, placed on opposite sides of the stem), the buds in their axils are consequently *opposite;* as in the Horse-Chestnut (Fig. 72), the Lilac (Fig. 74), &c. When the leaves are *alternate*, or one upon each node, as in the Oak (Fig. 927), the buds implicitly follow the same arrangement. Branches, therefore, being developed buds, their arrangement is not left to chance, but is predetermined, symmetrical, and governed by fixed laws. When the leaves are alternate, the branches will be alternate; as in the Oak, Poplar, Apple, &c. When the leaves are opposite, *and the buds develope regularly*, the branches will be opposite; as in the Horse-Chestnut, and other examples above cited.

74. But the regular symmetry of the plan of ramification is often accidentally interfered with or modified by secondary causes. Many of the buds often remain undeveloped. As the original embryo-plant remains for a time latent in the seed, growing only when a conjunction of favorable circumstances calls its life into action, so also many of the buds of a shrub or tree may remain latent for an indefinite time, without losing their power of growth. In our trees, most of the lateral buds generally remain dormant for the first season: they appear in the axils of the leaves early in summer, but do not grow into branches un-

til the following spring; and even then only a part of them usually grow. Sometimes the non-development or suppression occurs without appreciable order; but it often follows a nearly uniform rule in each species. Thus, when the leaves are opposite, there are usually three buds at the apex of a branch; namely, the terminal, and one in the axil of each leaf; but it seldom happens that all three grow at the same time. Sometimes the terminal bud continues the branch, the two lateral generally remaining latent, as in the Horse-Chestnut; sometimes the terminal one is regularly suppressed, and the lateral grow, when the stem annually becomes forked, as happens in the Lilac (Fig. 74).

75. The undeveloped buds do not necessarily perish, but are ready to be called into action in case the others are checked. When the terminal buds are destroyed, some of the lateral, that would else remain dormant, develope in their stead, incited by the abundance of nourishment, which the former would have monopolized. In this manner our trees are soon reclothed with verdure, after their tender foliage and branches have been killed by a vernal frost, or other injury. The buds may remain latent even for years, and become covered with wood. The trunk of a tree, therefore, always contains an immense number; some of which, after a long period, may force their way through the wood to the surface, and break forth into branches, especially when the tree is *pollarded*, or its leading branches injured. But many of the branches have a different and *abnormal* origin. We have already remarked, that irregular or adventitious buds are sometimes produced by the root, when surcharged with sap. Such buds are still more readily produced on woody stems, as we constantly observe on the pollard Willows and Lombardy Poplars. In several instances, buds are known to arise even from the surface or margins of leaves; as in Bryophyllum (Fig. 224), which

derives its name from this unusual circumstance. In trees, these adventitious buds are most liable to appear between the wood and bark where the trunk is wounded. These different causes, and others of more strictly accidental character, variously obscure and interfere with the predestined symmetry of the branches.

76. Buds, being, as it were, new individuals springing from the original stem, may be removed and attached to other parts of the parent trunk, or to that of another individual of the same, or even of a different, but nearly related species, where they will grow equally well. This is directly accomplished in the operation of *budding*. In *ingrafting*, the bud is transferred, along with a portion of the shoot on which it grew. Buds may even be made to strike root and grow independently, drawing their nourishment immediately from the soil, instead of indirectly through the parent trunk. This is done in the propagation of plants by cuttings. The great importance of these horticultural operations rests chiefly on the well known fact, that buds propagate *individual peculiarities*, which are more commonly lost in raising plants from the seed.

§ 3. Its various Forms.

77. On the size and duration of the stem the oldest and most obvious division of plants is founded; namely, into Herbs, in which the stem does not become woody, but dies, down to the ground at least, after flowering; Shrubs, which are woody plants, branched near the ground, and less than five times the height of a man; and Trees, which attain a greater height, with the stem unbranched near the ground. The stem of a tree is usually called a *trunk;* in Grasses, has been termed a *culm*. Botanists also distinguish Undershrubs, which are branching, partly woody plants, of small

height. But, as nature makes no abrupt transitions, such intermediate gradations everywhere occur, that it is often difficult strictly to define and apply these distinctions, which are nevertheless universally recognized.

78. Those stems which are too weak to stand erect are said to be *decumbent*, *procumbent*, or *prostrate*, when they recline or trail along the ground; and when they strike root at intervals, they are termed *creeping* stems. They are called *climbers*, when they cling to neighbouring objects for support; whether by tendrils, as the Vine and Passion-Flower; by their leaf-stalks, as the Virgin's Bower (Clematis Virginiana), or by aerial rootlets, as the Poison Oak (Rhus); and *twiners*, or twining plants, when they elevate themselves by coiling spirally around stems or other bodies within their reach. Other modifications of the stem or branches have received particular names, some of which merit notice from having undoubtedly suggested several important operations in horticulture.

79. A Stolon is a form of branch which curves or falls down to the ground, where, favored by shade and moisture, it strikes root, and then forms an ascending stem, which is thus capable of drawing its nourishment directly from the soil. The portion which connects it with the parent stem at length perishing, the new individual acquires an entirely separate existence. The Currant, Gooseberry, &c., multiply in this way, and doubtless suggested to the gardener the operation of *layering;* in which he not only takes advantage of and accelerates the attempts of nature, but applies it to species which ordinarily have no tendency to multiply in this manner.

80. A Sucker is a branch of subterranean origin, which, after running horizontally and emitting roots in its course, at length, following its natural tendency, rises out of the ground and forms an erect stem, which soon becomes an independ-

ent plant. The Rose, and Raspberry, and the Mint, afford familiar illustrations, as well as many other species which shoot up stems "from the root" as is generally thought, but really from subterranean branches. By cutting off the connection with the original root, the gardener propagates such plants *by division.*

81. A Runner, of which the Strawberry furnishes the most familiar example, is a prostrate, slender branch, sent off from the base of the parent stem, which strikes root at its apex, and produces a tuft of leaves; thus giving rise to an independent plant capable of extending itself in the same manner.

82. An Offset is a similar, but short, prostrate branch, with a tuft of leaves at the end, which, resting on the ground, there takes root, and at length becomes independent; as in the Houseleek.

83. A Spine is a short and imperfectly developed branch of a woody plant, contracted at the apex into a sharp, rigid point. Its structure is well exhibited in the compound spines of the Honey Locust. In the Wild Thorn (Cratægus), they often bear leaves; and, as the result of more vigorous growth, frequently disappear in those domesticated plants which bear them in a wild state, as in the Apple, and the Pear.

84. A Tendril is commonly a slender, leafless branch, capable of coiling spirally, by which climbing plants attach themselves to surrounding bodies; as in the Grape-Vine (Fig. 171). But sometimes tendrils belong to the leaves, as in the Pea.

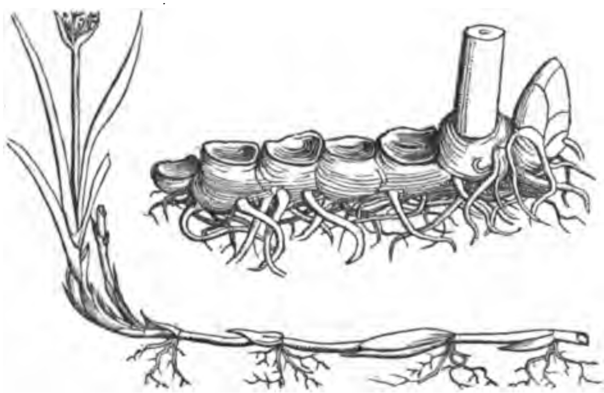
85. The subterranean modifications of the stem are scarcely less numerous and diverse than the aerial; but they may all be reduced to a few principal types. They are distinguishable from roots by producing regular buds, or by being marked with scars which indicate the former

insertion of leaves, or furnished with scales, which are the rudiments or vestiges of leaves. All the *scaly roots* of the older botanists are therefore forms of the stem or branches, with which they accord in every essential respect; they grow, also, in the opposite direction from roots. Of the same nature are what were formerly termed (as they are still popularly considered) *creeping roots*, although they are really subterranean branches, such as those of the Mint, and of many Sedges and Grasses which flourish in a purely sandy soil. Some of these, such as the Carex Arenaria (Fig. 75) of Europe, render important service in binding the shifting sands of the sea-shore. Others, like the Couch-Grass, are often very troublesome to the agriculturist, who finds it next to impossible to destroy them by the ordinary operations of husbandry; for, being furnished with buds and roots at every node, which are extremely tenacious of life, when torn in pieces by the plough, each fragment immediately becomes an independent plant. The Nut-Grass (Cyperus Hydra), an equally troublesome pest to the planters of Carolina and Georgia, is similarly constituted; and besides, the interminable subterranean branches bear tubers, or reservoirs of nutritive matter, in their course, which have still greater powers of vitality, as they contain a copious store of food for the development of the buds they bear.

86. A Rhizoma, or Rootstock (Fig. 76), is a similar prostrate stem, either subterranean or resting on the surface of the soil, which is thickened by the accumulation of nutritive matter in its tissue. The so-called *roots* of the Iris or Flower-de-luce, of the Calamus or Sweet Flag, and of the Blood-root, are of this kind. In their subterranean growth they follow the same laws as ordinary stems. The Solomon's Seal, and the Diphylleia (Fig. 76), offer simple illustrations. They make an annual growth by

the development of a bud at the point, which, rising into the air, forms the flowering stalk of the season, and, as it

75 76



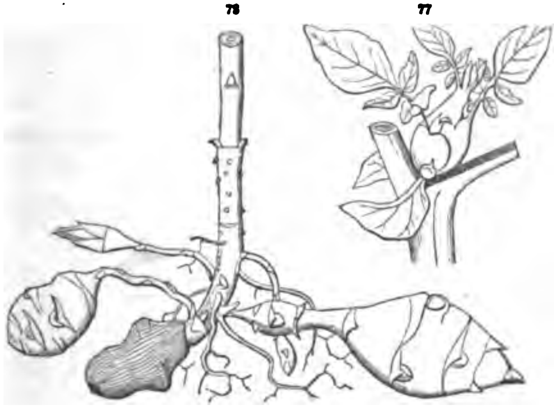
falls away in autumn, leaves a broad scar; meanwhile a new bud is produced at the apex, to form the stalk of the next summer; and so on. In this manner the rhizoma slowly moves onward from year to year, the scars marking the annual growth, and the more ancient portions gradually decaying as new parts are formed at the other extremity. The rhizoma, like other subterranean forms of the stem, serves as a reservoir of nourishment to maintain this annual growth, in the same manner as thickened roots. From the rhizoma we pass by regular gradations to the tuber.

87. A Tuber is formed by the enlargement of the apex (or growing bud) of a subterranean branch, the elongation of which is arrested, and the whole excessively thickened, by the deposition of starch, &c., in its tissue. This accumulation serves for the nourishment of the buds (eyes) which it involves, when they develope the following year. The common Potato offers the best and most familiar exam-

FIG. 75. Creeping subterranean stem of Carex arenaria.
FIG. 76. Rhizoma of Diphylleia cymosa.

ple; and it is very evident, on inspection of the growing plant, that the tubers belong to branches, and not to the roots. The nature of the Potato is also well shown by an accidental case (Fig. 77), in which some of the buds or branches above ground showed a strong tendency to develope in the form of tubers. By heaping the soil around the stems the number of tuberiferous branches is increased. The Jerusalem Artichoke affords a good illustration of the tuber (Fig. 78).

78 77



88. A Cormus, or Corm, is a fleshy subterranean stem, of a round or oval figure, and a uniform, compact texture; as in the Arum triphyllum or Indian Turnip (Fig. 82), the Colchicum, the Crocus (Fig. 86), the Cyclamen,* &c.

* The broad and flattened corm of Cyclamen arises from the dilatation of the first internode of the stem, that which preëxists in the embryo below the cotyledons or seed-leaves. In many

FIG. 77. A monstrous branch, or bud, of the Potato, showing a transition to the tuber. (From the Gardener's Chronicle.)

FIG. 78 Base of the stem of the Artichoke (Helianthus tuberosus), showing the nature of the tubers.

It may be compared to the globular stem of a Melon-Cactus, like which it has no power of elongation; or it may be viewed as a tuber or rhizoma reduced to the greatest simplicity, developing one or more buds from its summit, and emitting roots from its base. Corms are often termed *solid bulbs;* and, indeed, they are only a kind of bulb with the proper axis or stem more enlarged, and the investing scales nearly or altogether wanting.

89. A BULB is an extremely abbreviated stem, clothed with scales. It is a permanent, mostly subterranean, bud, the scales of which are more or less thickened and fleshy; — sometimes separate, thick, and arranged in several distinct rows, as in the *scaly bulb* of the Lily (Fig. 79); sometimes broad and thin, or the outer even membranaceous, and investing each other in concentric layers, as in the *tunicated bulb* of the Onion (Fig. 83), &c. In growing, they shoot forth a flowering stem from the centre, and emit roots from the base.

90. BULBLETS are buds with fleshy scales, which arise in the axils of the leaves of several plants, such as the common Lilium bulbiferum of the gardens (Fig. 81), and at length separate spontaneously, falling to the ground, where they take root, and become independent plants. In the Onion, and other species of the genus Allium, many of the flower-buds frequently change to bulblets. They plainly show the identity of bulbs with buds.

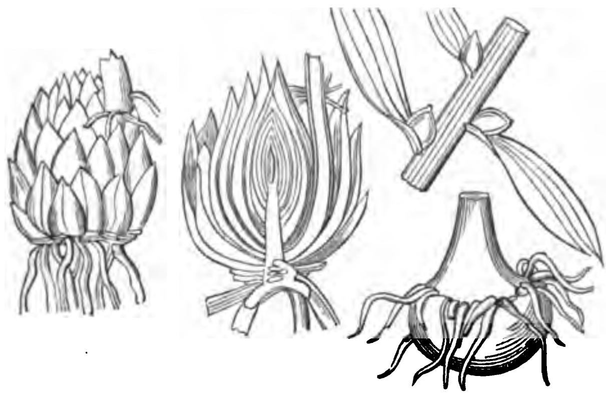
91. The regular plan of increase and ramification already described prevails in these extraordinary, no less than in the ordinary, forms of the stem. They grow and branch,

---

plants, this internode, or that immediately above the cotyledons, enlarges with the root. This occurs in the Turnip, Radish, Beet, &c.; where the *root* thus produced, or at least the upper part of it, presents the structure of the stem.

or multiply, by the development of terminal and axillary buds. This is perfectly evident in the rhizoma and tuber,

79 80 81



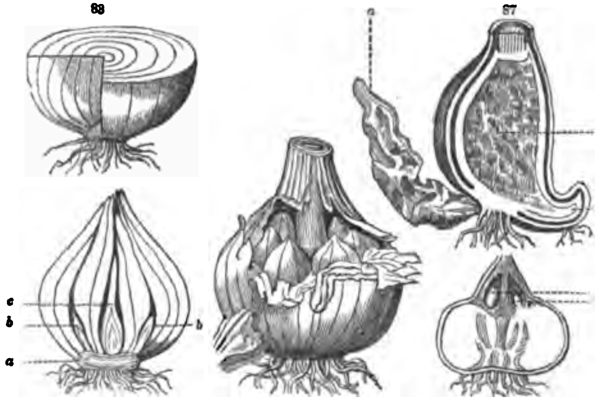
82

and is equally the case in the corm and bulb. The stem of the bulb is usually reduced to a mere plateau (Fig. 84, *a*), which produces roots from its lower surface, and leaves (the exterior of which are reduced to scales) from the upper surface. Besides the terminal bud (*c*), which usually forms the flower-stem, lateral buds (*b*) may be produced in the axils of the leaves or scales. One or more of these may develope as flowering stems the next season, and thus the same bulb survive and blossom from year to year (as is the case with the Tulip, Hyacinth, &c.); or these axillary buds may themselves become bulbs, feeding on the parent bulb, which in this way is often consumed by its own offspring, as in the Garlic (Fig. 85); or, finally separating from the living parent, just as the bulblets of the Tiger Lily fall from the stem, they may form so many independent individuals.

FIG. 79. The scaly bulb of a Lily. 80. A vertical section of the same. 81. Axillary bulblets of Lilium bulbiferum. 82. Cormus of Arum triphyllum.

So the old corm of the Crocus (Fig. 86) produces one or two new ones (*a*) near the apex, and gradually dies as they develope. That of the Colchicum produces a new bud near the base of the old, upon which it feeds, and is in turn destroyed by its own progeny the following year; so that we observe (Fig. 87), *a*, the shrivelled corm of the year preceding; *b*, that of the present season (a vertical section); and *c*, the nascent bud for the ensuing season.

83 87



84 85 86

92. Many of the forms which the stem assumes, when above ground, differ quite as much from the ordinary appearance as do any of these subterranean modifications; as, for example, the globular Melon-Cactus, the columnar Cereus, and the jointed Opuntia or Prickly Pear.

FIG. 83. Section of a tunicated bulb of the Onion.

FIG. 84. Longitudinal section of the bulb of the Tulip, showing its stem (*a*), and buds (*b*, *c*).

FIG. 85. Bulb of the Garlic, with a crop of young bulbs.

FIG. 86. Vertical section of the corm of Crocus: *a*, new buds.

FIG. 87. Vertical section of the corm of Colchicum, with the withered corm of the preceding (*a*), and the forming one (*c*) for the ensuing, year.

§ 4. Its Internal Structure.

93. Having considered the various external forms and appearances which the stem exhibits, and its mode of increase in length, our attention may now be directed to its internal structure, and mode of increase in diameter.

94. The stem embraces in its composition the various kinds of elementary tissue that have already been described (Chap. I.); namely, cells, woody fibre, and vessels. At first, indeed, it consists almost entirely of cellular tissue; a substance which ordinarily possesses much less strength and tenacity than woody fibre, and is therefore inadequate to the purposes for which the stem, in all the higher plants, is destined. The stem of a Moss is, in fact, composed of cellular tissue alone; and is therefore weak and brittle, well enough adapted to the humble size of that tribe of plants, but incapable of attaining any considerable height. Accordingly, as the stems of all the higher plants grow, and in proportion as the leaves are developed, woody fibre, &c., is introduced, *woven into* the original cellular fabric, to afford the requisite toughness and strength. Although most abundant in shrubs and trees, yet woody fibre enters more or less largely into the composition of the stems of all ordinary herbs.

95. The cellular part of the stem grows with equal readiness in whatever direction the forces of vegetation act. It extends vertically, to increase the stem in length; and horizontally, to increase its diameter. Into this the woody fibres and vessels are introduced vertically; they run lengthwise through the stem and branches. Hence, the latter may be called the *vertical* or *perpendicular system*; and the cellular part, the *horizontal system* of the stem. Or the stem may be compared to a web of cloth; the cel-

lular system forming the *woof*, and the woody, the *warp*. It will be seen hereafter, that this illustration not inaptly represents the real structure of the stem.

96. The diversities in the internal structure of the stem are principally owing to the different modes in which the woody or vertical system is imbedded in the cellular. These diversities are reducible to two general plans; upon one or the other of which the stems of all Flowering Plants are constructed. Not only is the difference in structure quite striking, at least in all stems more than a year old, but it is manifested in the whole vegetation and aspect of the two kinds of plants, and indicates the division of Flowering Plants into two great classes, recognizable by every eye; which, in their fully developed forms, may be represented, one by the Oak and the other trees of our climate, the other by the Palm (Fig. 98[a]).

97. The difference between the two, as to the structure of their stems, is briefly and simply this. In the first, the woody system is deposited in *annual concentric layers* between a *central pith* and an *exterior bark;* so that a cross section presents a series of rings or circles of wood, surrounding each other and a distinct pith, and all surrounded by a separable bark. This is the plan not only of the Oak, but of all the trees and shrubs of the colder climates. In the second, the woody system is not disposed in layers, but consists of separate bundles or threads of woody fibre, &c., running through the cellular system without apparent order; and presenting on the cross section a view of the divided ends of these threads in the form of dots, diffused through the whole; but with no distinct pith, and no bark which is

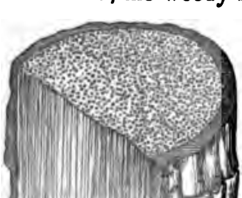

88

FIG. 88. Section of a Palm-stem.

at any time readily separable from the wood. The appearance of such a stem, both on the longitudinal and the cross section, is shown in Fig. 88; it may also be examined in the Cane or Rattan, the Bamboo, or even in a stalk of Indian Corn or Asparagus. That of ordinary wood of the first class is too familiar to need a pictorial illustration.

98. The stem, in the first case, increases in diameter by the annual formation of a new layer of wood, which is deposited between the preceding layer and the bark; in other words, the wood increases by annual additions to the outside. Hence, such stems are said to have the EXOGENOUS structure; and the Flowering Plants whose stems grow in this way are called EXOGENOUS PLANTS, or briefly EXOGENS; that is, as the term literally signifies, *outside-growers.*

99. In the second case, the new woody matter is deposited within the old, and towards the centre, which is more and more occupied with the woody threads as the stem grows older; and increase in diameter, so far as it depends on the formation of new wood, generally takes place by the gradual distention of the whole, the new wood pushing the old outwards. Accordingly, these stems are said to exhibit the ENDOGENOUS structure or growth; and the plants of that division are called ENDOGENOUS PLANTS, or ENDOGENS; literally, *inside-growers.*

100. We have already had occasion to remark, that the character of the future plant is impressed upon the embryo (43, 72); and we may here barely premise, that these two great classes of plants are distinguishable, even in the embryo state, by a difference quite as marked as those which prevail in their whole port and aspect. The embryo of all plants that have endogenous stems bears only a single cotyledon or seed-leaf (45); hence, Endogens are also called MONOCOTYLEDONOUS PLANTS. The embryo of plants

with exogenous stems bears a pair of cotyledons (Fig. 52); hence Exogens are likewise called DICOTYLEDONOUS PLANTS. We explain these terms in advance, as it may occasionally prove convenient to employ them.

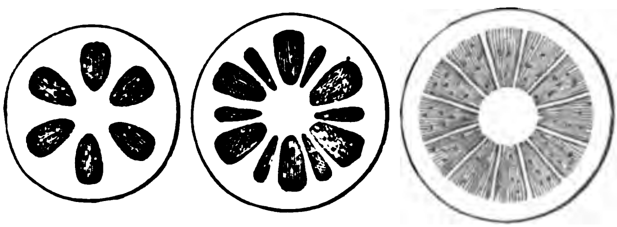
§ 5. OF THE EXOGENOUS OR DICOTYLEDONOUS STEM IN PARTICULAR.

101. Since the Exogenous class is by far the largest in every part of the world, and embraces all the trees and shrubs with which we are familiar in the cooler climates, the structure of this kind of stem demands more detailed notice. To obtain an accurate and clear idea of its internal structure, we should commence at its origin and follow the course of development.

102. In the embryo state, or at least at some period antecedent to germination, the rudimentary stem is entirely composed of cellular tissue (22). But as soon as it begins to grow, vessels and woody fibre appear; and by the time that two or three internodes and leaves are developed (as in Fig. 56), the young stem will be found to be traversed vertically by several bundles of woody and vascular tissue intermixed, which represent the first rudiments of its woody system. These bundles, taken together, are disposed in a circle (so that the cross section appears as represented in the annexed diagram, Fig. 89), and naturally assume a wedge-like shape. As the stem developes, these woody bundles increase in number, and nearly fill the intervening spaces (as in Fig. 90 and 91). Thus, in the course of the season, a circle or layer of wood is formed, which is in such a way imbedded in the original homogeneous cellular system as to divide it into two parts; namely, a central portion, which forms the pith, and an exterior zone, which belongs to the bark. The whole is of course invested by the

skin or epidermis which covers the whole surface of the plant (38).

103. It will be observed (Fig. 89–91), that the woody



89 90 91

bundles are separated from each other by bands of the original cellular tissue which pass from the pith to the bark, and which necessarily become narrower and more numerous as the woody bundles or wedges increase in number. These are the MEDULLARY RAYS, which form the radiating lines that the cross section of most exogenous wood plainly exhibits, especially that of the Oak, Plane, &c. They are the remains of the cellular system of that part of the stem, condensed by the pressure of the woody wedges, or plates, and which serve to keep up the communication between the pith and the bark.

104. An exogenous stem of the first season, therefore, consists of three principal parts; namely, 1st. a central cellular portion, or *pith;* 2d. a *layer of wood;* and 3d. an outer cellular portion, or *bark.* An herbaceous stem does not essentially differ from a woody one of this age, except that

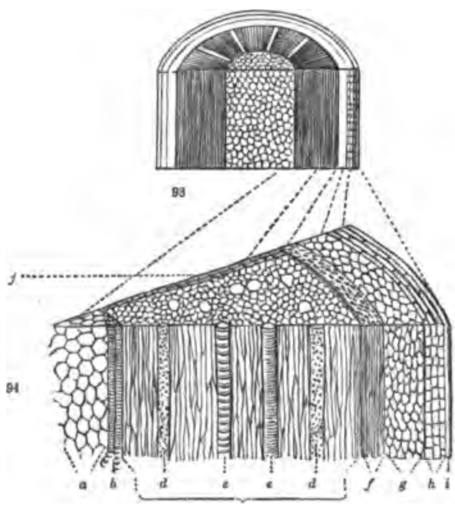
FIG. 89. Plan of a cross section of a young seedling stem, showing the manner in which the young wood is embedded in the cellular system.

FIG. 90. The same at a later period, the woody bundles increased so as nearly to fill the circle.

FIG. 91. The same at the close of the season, where the wood has formed a complete circle, separating the pith from the bark, except that they are still connected by narrow portions of the cellular system (the *medullary rays*) which radiate from the pith to the bark.

the pith and the medullary rays are perhaps much larger in proportion to the wood. Fig. 92 represents a section of a woody exogenous stem, a year old, of the natural size. Fig. 93 shows a portion of the same, magnified, so that the

92



different parts may be distinguished, both on the longitudinal and transverse section: and Fig. 94 is a much more mag-

FIG. 92. Longitudinal and transverse section of a stem of the Soft Maple (Acer dasycarpum) at the close of the first year's growth; of the natural size.

FIG. 93. Portion of the same, magnified, showing the cellular pith, surrounded by the wood, and that enclosed by the bark.

FIG. 94. More magnified slice of the same, reaching from the bark to the pith; *a*, part of the pith; *b*, vessels of the medullary sheath; *c*, the wood; *dd*, dotted ducts in the wood; *ee*, annular ducts; *f*, the liber, or inner, fibrous bark; *g*, the cellular envelope, or green bark; *h*, the corky envelope; *i*, the skin or epidermis; *j*, one of the medullary rays, seen on the transverse section.

nified view of a slice of the same, reaching from the bark to the pith.

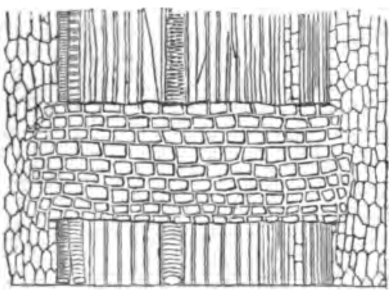
105. The PITH (Fig. 93, 94, *a*) consists entirely of soft cellular tissue, or parenchyma (26), which is at first gorged with the nourishing juices of the plant. These are in time exhausted, leaving the older pith dry and light, or mere empty cells which are of no further use to the plant. Many stems expand so rapidly in diameter during their early growth that they become hollow, and the pith forms a mere lining to the cavity, as in grasses and other herbs, or else is separated into horizontal plates, as in the Poke (Phytolacca) and the Walnut.

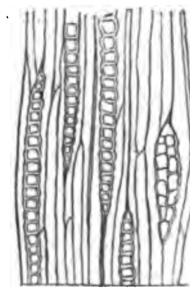
106. Among the earliest woody tissue that is formed in the stem, if not anterior to its production, a set of spiral vessels appear, which are arranged in a circle immediately around the pith. These constitute what has been termed the MEDULLARY SHEATH, and is the only part of an exogenous stem in which spiral vessels usually occur. These vessels, as brought to view in the vertical section, Fig. 94, are shown at *b*.

107. The WOOD (Fig. 94, *c*) consists of woody fibre, among which vessels are more or less copiously mingled, principally in the form of dotted ducts (*d*), with occasional annular ducts (*e*), &c., which are of so considerable calibre, that they are conspicuous to the naked eye in many ordinary kinds of wood. Sometimes these are scattered indiscriminately through the wood, as in the Maple. Sometimes they are accumulated in the inner portion of each layer, as in the Oak.

108. In Fig. 94, the vertical section passes directly through the middle of one of the woody plates that collectively compose the layer; and therefore the medullary rays do not appear. But in the much more magnified Fig. 95, the section is made so as to show the surface of one of

these plates, and one of the MEDULLARY RAYS passing horizontally across it, connecting the pith (*p*) with the bark (*b*). These medullary rays form the ***silver-grain***, (as it is





p 95 *b* 96

termed,) which is so conspicuous in the Maple, White Oak, &c., and which gives the glimmering lustre to many kinds of wood when cut in this particular direction. But a section made as a tangent to the circumference, and therefore perpendicular to the medullary rays, brings their ends to view, as in Fig. 96; much as they appear when seen on the surface of a piece of wood from which the bark is stripped. They are evidently composed of cellular tissue merely, and their origin has already been explained (103). They represent the horizontal system of the wood, or the *woof*, into which the vertical woody fibre, &c., or *warp*, is interwoven. The inspection of a piece of oak or maple wood at once shows the pertinency of this illustration.

109. The BARK, in a stem of a year old, must next be more attentively considered. At first (102) it consisted of simple cellular tissue, or parenchyma, undistinguishable from that of the pith, except it assumed a green color when

FIG. 95. Vertical section through the wood of a branch of the Maple, a year old; so as to show one of the medullary rays, passing transversely from the pith (*p*) to the bark (*b*).

FIG. 96. A vertical section across the ends of the medullary rays; magnified.

exposed to the light, from the production of *chlorophylle* (36) in its cells. But during the formation of the proper woody layer, an analogous formation occurs in the bark itself. In its inner portion, a layer of woody and vascular tissue is deposited, chiefly in the form of tough woody fibre, which constitutes the *inner, fibrous bark*, or LIBER (Fig. 94, *f*). This rests, as every one knows, directly on the wood. The cellular portion, which covers the liber, occupying the space between it and the epidermis or skin, is likewise soon distinguishable into two parts; namely:— 1st. The *green layer* or CELLULAR ENVELOPE (Fig. 94, *g*); also technically called the *mesophlœum*, because it is situated between the *endophlœum* (literally inner bark) or liber, and the *epiphlœum* or outer integument. This is the only part of the bark that assumes a green color. It is identical in composition with the green pulp of leaves, which, we shall perceive, may be deemed to arise from it. 2d. The CORKY ENVELOPE, or *epiphlœum* (Fig. 94, *h*), which lies between the latter and the epidermis (*i*), and which is generally of a brownish or ash color. It is this which, taking an unusual development, forms the *cork* of the Cork-Oak, and those corky expansions of the bark which are so conspicuous on the branches of the Sweet Gum (Liquidambar), of some of our Elms (Ulmus alata and racemosa), &c. It also forms the paper-like exfoliating layers of Birch-bark.

110. To recapitulate in detail the elements which compose the fabric of an exogenous stem of a year old, especially in a woody plant, we find, proceeding from the centre towards the circumference,—

I. In the wood:

1. The *pith*, belonging to the cellular or horizontal system.
2. The *medullary sheath*, } which belong to the woody or
3. The *layer of wood*, } vertical system.

4. The *medullary rays*, a part of the cellular system, which traverses the wood horizontally.

II. In the bark:

5. The *liber*, which belongs to the woody or vertical system; and which, we should have remarked, is traversed horizontally by a continuation of the medullary rays of the wood.
6. The *outer bark*, belonging to the cellular system, and composed of two parts, namely, 1st, the *green or cellular layer*, and 2d, the *corky layer*.
7. The *epidermis* or skin, which invests the whole.

111. An herbaceous stem takes no further development, but perishes at the close of the season; that of a shrub or tree makes an addition to its fabric the following year, which we are now prepared to consider.

112. In the spring, when its growth is about to recommence, a kind of mucilage appears between the then readily separable bark and wood, which is named the CAMBIUM, and which is supposed to be the nourishment of the forming wood. In it, or from it, new cells and vessels are developed, and a new layer of wood is produced like the first, which it incloses. The liber is at the same time increased in thickness by the addition of a new layer to the inside. Each successive year a new layer is added to the wood in the same manner, and also to the bark; each layer being, like the first, intersected by the extended medullary rays. A cross section of such a stem, therefore, exhibits the wood disposed in concentric layers between the bark and the pith; the oldest lying next the latter, or in the centre, and the youngest occupying the circumference. Each layer being the product of a single year's growth, the age of an exogenous tree may, in general, be correctly ascertained by counting the rings in a cross section of the trunk.

113. The reason why exogenous wood presents these

distinct layers, instead of an uniform compact appearance, is principally because the constituents of each layer are not uniformly distributed throughout its thickness. In the Oak, Chestnut, and many other trees in which the annual rings are very distinctly marked, the ducts of each layer are nearly all accumulated towards the inner margin of each layer, where, on the cross section, their large, open mouths form a conspicuous circle of pores, while the outer part of the ring appears solid, being entirely composed of woody fibre. Even where the ducts are scattered, as in the Maple and Elm, or perhaps entirely absent, as in the Pine, the wood near the outer border of each layer is more compact and finer-grained or deeper colored, so that the line of demarcation between contiguous layers is still generally evident. The layers are more likely to prove indistinct in the case of trees within the tropics, where the growth is not interrupted by winter; but even in these climes there is generally a more or less marked annual suspension of vegetation, occurring, however, rather in the hottest than the coolest season (149).

114. There are cases, however, in which the wood appears to form a uniform stratum, whatever be the age of the trunk, as in the arborescent species of Cactus; or where the layers are few and by no means corresponding with the age of the trunk, as in the Cycas. In some woody climbing or twining stems, such as those of our Aristolochia Sipho and Menispermum Canadense, the annual layers are at most very obscurely marked, while the medullary rays are excessively broad, and the wood therefore forms a series of separable wedges disposed in a circle around the pith. In the stem of one of our Trumpet-Creepers (the Bignonia capreolata) the annual rings, after the first four or five, are interrupted (owing to the unequal distribution of the new wood around the circumference) by

four broad lines of cellular tissue, passing at right angles to each other from the circumference towards the centre, so that the cross section of the wood nearly resembles a Maltese cross. But these are all exceptional cases, which scarcely require notice in a general view.

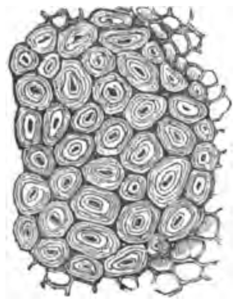
115. The wood of the Pine, Yew, Cypress, and the whole tribe of what are called *Coniferæ*, or cone-bearing trees, is characterized by its uniformity of structure, being formed of woody fibre with no intermixture of ducts, and by having the walls of these woody tubes marked with rows of circular disks, as in Fig. 29, 30. Something like the same appearance is seen in the wood of the Magnolia, &c.

116. The layer of wood forms a system of innumerable tubes, none of them of great length, but closely fitted, and together reaching from the extremity of the roots to the apex of the stem; through which (chiefly through the proper woody tissue, which is at first very permeable to fluid) the sap is conveyed upwards into the leaves. Hence the new wood is called SAP-WOOD. The early physiologists also gave it the name of the ALBURNUM from its whitish color. The crude sap, or fluid which the roots absorb, has necessarily dissolved from the soil a small but variable quantity of earthy matter, such as the salts of potash, lime, &c., — all the earthy materials of wood-ashes. A portion of this the sap in its course deposits in the woody tubes, forming an incrustation which gradually diminishes their calibre. Besides, a portion of organized matter, and of the plant's peculiar products, are also deposited in the wood (28). Thus the wood grows denser as it increases in age, and usually changes its color, becoming dark brown in the Black Walnut, black in the Ebony, reddish in the Red Cedar, &c. It is then called DURAMEN, or HEART-WOOD. The appearance of the woody tubes, when their walls are thickened in this way, is shown in Fig. 26. In time, the cavity

is perhaps entirely obliterated, when the older wood no longer serves for the conveyance of the sap, nor takes any active part in the circulation. The harder and more solid heart-wood is therefore not only stronger, but more durable, being less surcharged with fluid, and no longer hygrometrical, so as to be affected by atmospheric moisture. That the color is owing to a deposition in the tissue may be proved by throwing pieces of the wood into nitric acid or some other solvent; when this matter is dissolved, and the wood again becomes colorless. The heart-wood, no longer assisting in any of the vital actions, may die and decay, as it frequently does, without other injury to the plant. Each layer of wood, once formed, remains unaltered in dimensions and position, and unchangeable except from decay.

117. But the bark is necessarily subject to grave alterations with advancing age, on account of the constantly increasing diameter of the stem, as well as from its own mode of growth. The inner bark, or liber (109), increases, like the wood, by annual layers; but the new layers are deposited on the side next the wood, that is, within the old bark, which is therefore pushed outwards by the new formation, and especially by the new layers of wood. The fibrous tubes of the liber, which bear an important part in the downward circulation of the plant, are also solidified, much like the heart-wood, by the deposition of encrusting matter. This is shown in Fig. 97, which represents a section of a piece of old liber from the White Birch. The older and outer layers of the liber therefore become inactive, or finally die, and, no longer accommodating themselves to the enlarging stem, are at length riven and torn into strips, and fall away by gradual decay, as we see in the trunks of large trees. The bark consequently bears but a small proportion in thickness to the wood in old stems, varying greatly, however, in different species. In the Vine

and Honeysuckle (Lonicera) the new liber annually detaches that of the year preceding. In many trees the lay-



97

98

ers of a long series of years may be distinctly counted. Both the cellular integument and the corky envelope, which together compose the outer bark (109), grow by the multiplication of their cells, each independently of the other, though this growth does not generally take the form of regular layers. The growth of both, however, is often arrested at an early period; they are also subject to decay from the action of the elements, and are of course finally riven or torn into strips or plates with the liber. Sometimes the corky envelope is early abraded by the weather, and thrown off with the epidermis; sometimes it takes a very great development, as in the Oak that produces the common Cork, &c. In the Birch, it is composed of two kinds of cells; the one flat and tabular (Fig. 98, *a*), and firmly coherent in several series; the other (*b*) nearly cubical, delicate, and with comparatively little cohesion, forms alternate layers with the first sort. The delicate cubical cells being readily broken up by the expansion of the stem, the tabular

FIG. 97. Highly magnified cross section of a bit of the old liber of the bark of the Birch; the tubes nearly filled with a deposit of solid matter.

FIG. 98. Cross section of a bit of the corky envelope of the same, highly magnified.

tissue separates in the form of those thin paper-like layers so characteristic of the Birch, and which are particularly beautiful in the Betula papyracea or Paper-Birch. In the Beech, where the tabular cells alone develope, the strata are not separable in this manner. In the Pine and Spruce, it is the cellular envelope, peculiarly developed and forming a kind of false cork, which makes up the principal thickness of the bark, and in age falls away from the surface in the form of brittle plates or scales.

118. The woody tissue of the bark is generally composed of more slender, tougher, and more flexible fibres than those of the wood. It is these which are turned to such important account, as the materials of cordage, linen, &c. As examples, we need only mention the Hemp-plant and the Flax, where the fibres of the liber are alone employed. The mode of preparation shows how much more solid and resistent these fibres are than any other tissue of the plant, since they are left after maceration and mechanical operations that destroy all the other tissues.

119. The elaborated juices of the plant are returned from the leaves into the bark, so that peculiar secretions are often deposited in it, and medicinal and other principles are there to be sought, rather than in the wood.

120. Since the old bark and the heart-wood bear no further part in the active circulation or growth of the tree, and the one is in time thrown off at the surface, and the other may decay without injury, except by mechanically weakening its strength, it is obvious that the sap-wood and the liber are alone permanently essential to the existence of the trunk.

121. Exogenous plants almost always develope axillary buds, and produce branches: hence their stems and branches gradually taper upwards, or are conical.

§ 6. Of the Endogenous or Monocotyledonous Stem.

122. A cursory notice must now be taken of the stem of Endogens (or *Inside-growers*), a great class of plants, which,

98²

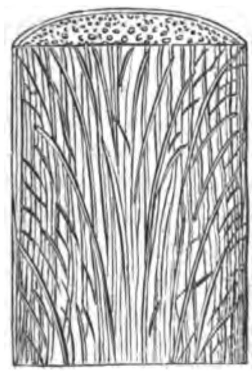
although they have many humble representatives in northern climes, yet only attain their full characteristic development, and display their noble arborescent forms, under a

FIG. 98². The Chamærops Palmetto, in various stages, and the Yucca Draconis.

tropical sun. Yet Palms — the type of the class — do extend as far north in this country as the coast of North Carolina (the natural limit of the Palmetto, Fig. 98[a]); while in Europe the Date and the Chamærops have found their way to the warmer parts of the European shore of the Mediterranean. Their mode of growth gives them a striking appearance; their trunks being unbranched cylindrical columns, rising majestically to the height of from thirty to one hundred and fifty feet, crowned at the summit with an ample plume of graceful and peculiar foliage. Their internal structure is equally different from that of ordinary wood.

123. The stem of an Endogen, as already remarked (99), offers no manifest distinction into bark, pith, and wood; and the latter is not composed of concentric rings or layers, nor traversed by medullary rays. But it consists of bundles of woody and vascular tissue, in the form of thick fibres or threads which are imbedded, with little apparent regularity, in cellular tissue; and the whole is inclosed in an integument which does not strictly resemble the bark of an Exogenous Plant; inasmuch as it does not increase by layers, and is never separable from the wood. The fibrous bundles which represent the wood, and which consist of a mass of woody fibres surrounding several vessels, are somewhat equably distributed throughout the cellular system of the stem, but without being arranged in layers. They may be traced directly from the base of the leaves (in which they doubtless originate) down through the stem, some of them to the roots in a young plant, while others, curving outwards, lose themselves in the cortical integument, or rind. As the stem increases, new bundles, springing from the bases of more recently developed leaves, are at first directed towards the centre of the stem, along which they descend for a considerable distance, then, curving outwards, they mostly terminate in the rind. It is in consequence of

the cohesion of these obliquely descending fibres to the false bark, that the latter cannot, as in Exogens, be separated from the wood beneath. The manner in which the woody threads are consequently interwoven is shown in Fig. 99. The palm-like Yuccas of the Southern States offer beautiful illustrations of the kind. The appearance on a cross section of an endogenous stem is shown in Fig. 88.



99

124. The new woody bundles which are added from year to year, instead of arranging themselves outside the earlier wood and inclosing it, as in Exogens, actually descend more in the centre, and gradually force outward those which were first formed. Such a stem, therefore, instead of having the oldest and hardest wood at the centre and the newest and softest at the circumference, as in ordinary trees, is softest towards the centre and most compact at the circumference. In this way, and by the general growth of the cellular tissue in which the fibro-vascular bundles are imbedded, the stem increases in diameter as long as the rind is capable of distension. In some instances, as in the arborescent Yuccas and the Dracænas or Dragon-trees, the rind remains soft and capable of unlimited expansion; but in the Palms, and in most woody Endogens, it soon indurates, and the stem consequently can increase no further in diameter. The wood of the lower part of such stems is more compact than the upper, being more filled with woody bundles, and the rind is harder, from the greater number of

FIG. 99. Vertical and transverse section of a young Endogenous stem.

ligneous fibres which terminate in it, and from its proper induration. Further increase in diameter being in these cases impossible, and the lower part of the stem becoming at length choked up by the multitude of descending bundles, it appears that the life of such Endogens must be limited.

125. Palms, &c., generally grow from the terminal bud alone, and perish if this bud be destroyed; the foliage is also borne in a cluster at the summit of the trunk; which consequently forms a simple cylindrical column. But in some instances two or more buds develope, and the stem branches, as in the Doon-Palm of Upper Egypt, and in the Pandanus, or Screw-Pine (Fig. 63), which belongs to a family closely allied to Palms: in such cases the branches are cylindrical. But when lateral buds are freely developed, or the leaves are scattered along the stem or branches (as in the Bamboo, Maize, Asparagus, &c.), these taper upwards, just as in Exogens.

126. The Grasses have endogenous stems, mostly of annual duration, and which early become hollow, in the manner already indicated (105). In several, such as the Maize and Sugar-Cane, the stem remains solid; and these furnish good examples of ordinary endogenous structure.

§ 7. Of the Theoretical Structure of the Stem, and the Origin of the Wood.

127. The foregoing general view of the structure and growth of the stem, &c., has as far as practicable been kept free from theoretical considerations. Yet we have tacitly assumed, at least in the case of endogenous stems, that the wood is formed, or grows, from above downwards, and that it originates in the leaves. But as this view, though long since suggested, and in later times reproduced under several forms, has only quite recently become preva-

lent, and is not universally admitted by the physiologists of the present day, — and is besides in direct conflict with the current popular notions upon the subject, — it is proper to state generally the evidence by which it is thought to be sustained. The connection between the wood and the leaves is most readily demonstrated in endogenous stems, such as those of Yucca, where the woody threads may with ease be traced from the base of the leaf into the stem, and downwards to their termination in the root or the rind. But this does not decide the question whether the woody tissue grew in an upward or downward direction. The following considerations may be adduced to show that the *wood* is deposited or produced *from above downwards*. (1.) When a ligature is closely bound around a growing exogenous stem, the part above the ligature swells; that below does not. Every one may have observed the distortions that twining stems thus accidentally produce upon woody exogenous trunks. On examination, the woody fibres are found to be arrested at the upper margin of the ligature and thrown into curved and knotted forms; or, where the ligature is spiral, the descending fibres follow the course of the obstruction. (2.) When we girdle an exogenous stem, by removing a ring of bark so as completely to expose the surface of the wood, the part above the ring enlarges in the same manner; that below does not, except by the granulation of cellular tissue, until the incision is healed. (3.) In a graft, the descending wood of the scion may often be seen to be quite distinct from the stock; the latter sometimes dies while the scion continues to grow. (4.) In many specimens of wood of different species, the fibres are found to take a very sinuous course, when there is no obstruction or evident cause of disturbance; the fibres of adjacent layers even crossing each other at right angles. That these descending fibres in some way originate in the leaves is

shown: (1.) By tracing them directly into the bases of the leaves, as already remarked. (2.) Because the amount of wood formed in a stem or branch is in direct proportion to the number and size of the leaves it bears; its amount in any portion of the branch in direct proportion to the number of leaves above that portion. Thus, when the leaves are distributed along a branch, it tapers to the summit, as in a common Reed or stalk of Indian Corn; when they grow in a cluster at the apex, it remains cylindrical, as in a Palm (Fig. 98[a]). Consequently the aggregate diameter of the branches is (*cæteris paribus*) equal to that of the trunk from which they arise; as is beautifully illustrated by the *excurrent* stem of Pines and Firs, (carried directly upwards by the continued growth of the leading shoot,) the diameter of which regularly diminishes as the lateral branches are given off. Consequently the increase of the trunk in diameter directly corresponds with the number and vigor of the branches. The greater the development of vigorous branches on a particular side of a tree, the more wood is formed and the greater the thickness of the annual layers on that side of the trunk. (3.) In a seedling, wood is not produced until leaves are developed for its production; and the wood appears just in proportion as the leaves are developed. (4.) If a young branch be cut off just below a node (68), so as to leave an internode without leaves or bud, no increase in diameter will take place down to the first leaf below. But if a bud be inserted into or ingrafted upon this naked internode, as the bud developes, increase in diameter, with the formation of new wood, recommences.

128. We may now draw the general conclusions to which these and a great variety of similar facts evidently lead. We have seen (72), that lateral buds develope into branches, just as the original embryo developed into the primary stem. Now the original embryo, the primary

bud, as it may strictly be called, not only grew upwards to form the stem, but downwards to form the root. Buds grow upwards into branches; have they aught corresponding to the downward growth which in the original stem is represented by the roots? The answer is furnished by those buds which may be made to grow independently of the parent stem; such, for instance, as the bulblets of the Tiger Lily (Fig. 81), which are merely axillary buds with fleshy scales, and which, when they fall to the ground, or even while yet in their native situation, emit rootlets from their base, whose downward growth corresponds to the upward growth of the stem to which the bud gives rise. The same evidence is furnished by those ordinary buds which naturally grow in union with the parent, but which the gardener transfers to the soil in the form of cuttings (which are merely buds with a small piece of the stem), where they throw out roots from the base and grow into independent plants. As the bud, excited by warmth and moisture, developes upwards into a stem, just as it would have done into a branch had it remained in union with the parent, so it strikes root downward from the base of the cutting, and the fibres of these roots may be traced back directly to the bud. Evidently the fibres, which may be traced *as wood* from the bud down to the base of the cutting, are prolonged beyond into *roots*. The resemblance between the original stem and the branches it bears, therefore, holds good throughout. As the downward growth of the original stem gives rise to roots, so the downward growth of the lateral buds, when they grow in connection with the parent stem, contributes to the wood, and at length terminates in roots.

129. The branches of each year's growth are, therefore, kept in fresh communication, by means of the newest layer of wood, with the extremities of the roots; which are alone

active in absorbing the crude food of the plant from the soil. The fluid they absorb is thus conveyed directly to the branches of the season; which alone develope leaves to digest it. And the food they receive, having been elaborated and converted into organic nourishing matter, is partly expended in the upward growth of new branches, and partly in the downward formation of a new layer of wood, reaching from the highest leaves to the remotest rootlets. These two essential organs, namely, the rootlets which absorb, and the leaves which digest, the plant's nourishment, are, therefore, annually renewed; and, whatever their distance or the age of the tree, are maintained in fresh communication through the new annual layers. As the exogenous tree, therefore, annually renews its buds and leaves, its wood and roots, every thing, indeed, that is concerned in its life and growth, there seems to be no reason — no necessary cause inherent in the tree itself — why it should not live indefinitely.*

130. In layering (79), the gardener finds that roots strike more readily when an incision is made into the stem where it is covered with the soil. The evident explanation is, that the descending woody fibres, arrested by the incision, are forced, as it were, to strike at once into the soil, instead of pursuing the longer course through the main trunk to the same ultimate destination. This is the very economy of shrubs and trees which naturally multiply by suckers and stolons (80); from which the singular Banyan (Fig. 65), that in time spreads into a grove,

"High over-arched, with echoing walks between,"

* The subject of the longevity of trees has been ably discussed by De Candolle, in the *Bibliothèque Universelle* of Geneva, for May, 1831, and in the second volume of his *Physiologie Végétale*. In this country an article on the subject has appeared in the *North American Review*, for July, 1844.

in no wise differs, except that the roots strike and the whole process goes on in the open air. In this case, portions of the new wood merely take another and nearer course to the ground in the form of aerial roots, which in time produce additional trunks, instead of continuing their adhesion to the branches, and contributing to the increase in diameter of the main trunk. The additional trunks thus produced, and which eventually, by separation, may form the stems of independent trees, exactly represent the outer and newer layers of ordinary trees, of which the main stem represents the old and often decaying centre.

131. These considerations bring clearly to view the true nature of the vegetable, as *a composite being or structure.* A tree, for example, in a just philosophical sense, is not a simple indivivual (as is man and the higher animals); but is strictly a community, or an aggregate, like the compound animals of lowest grade, which are blended into a general body and nourished in common; — like a mass of arborescent coral, which is built up, as is well known, by the combined labors of a vast number of individuals. The vegetable is in like manner an aggregate of many individuals, which, though developed in union with the parent trunk, are capable of growing by themselves, which may be made to live independently, and often do in various ways (as by bulbs, tubers, layers, stolons, offsets, &c.) spontaneously acquire a separate existence. Each *bud* or *branch* is therefore the real *individual.* To apply this name in other than a mere popular sense to the composite tree, would lead to the absurdity of an individual consisting of several species; since the Apple, Pear, Quince, Medlar, and Hawthorn, may all, by ingrafting, be combined in a single tree. It would also oblige us to consider as a single individual all the plants which have arisen from the subdivision of an original

stem, — for example, perhaps all the Lombardy Poplars in this country, or even a large part of the Potatoes of Europe and America. In actual practice, the term ***individual plant*** is applied to the aggregate stem and branches while they remain united, but no longer.*

* The theoretical view expounded in this section is essentially that of La Hire and Du Petit-Thouars. It has recently received a further and very ingenious development by M. Gaudichaud, of the French Institute; who, in the course of three scientific voyages of circumnavigation, has enjoyed, and ardently and skilfully improved, the finest opportunities for physiological researches in almost every clime. M. Gaudichaud's views are given in an elaborate memoir in the *Memoirs of the Academy of Sciences* (in Vol. VIII. of the *Mémoires par Savants Étrangers*, 1843; but separate copies were issued a year or two previous), and in a series of recent articles in the *Annales des Sciences Naturelles*. His theory is essentially that of Thouars, reduced to its ultimate analysis, and to a somewhat more hypothetical expression. He does not stop with the bud, which is merely an undeveloped stem, or branch, but distinguishes it into its constituent parts, namely, the axis, and the leaves it bears, and traces the woody and vascular tissues from the latter into the former. It is the leaf that originates the woody tissues and makes the downward growth. It is the leaf accordingly, and not the composite bud, in which vegetable individuality really consists.

To obtain the simplest view of the nature and structure of the vegetable upon any theory, we must go back to the embryo, upon which the laws of vegetation are impressed, and the early development of which affords the simplest expression of these laws. According to the view of Thouars, the embryo in the seed is merely a bud, or rather a joint of stem, with the undeveloped stem, or bud, upon its summit. Gaudichaud merely analyzes this embryo-bud into its integral elements. With him, the *monocotyledonous embryo* exhibits the typical plant in its simplest condition. This simple individual, or *phyton*, as Gaudichaud terms it, consists of an ascending portion, the *cotyledon*, which in germination de-

CHAPTER V.

OF THE LEAVES.

§ 1. Their Internal Structure and Physiology.

132. The fundamental organs of the vegetable, namely, the root, stem, and leaves, are so intimately associated and

---

velopes into a leaf; a middle portion, which represents the first internode of the stem, and which from its base grows downwardly into a root. The woody tissue formed in the blade of the leaf grows downwardly into the first joint of stem, and thence into the root. Thus we have the *simple plant;* with its stem, leaf, and root. It may be viewed as *a leaf*, consisting of a blade, with its stem-part or base, which, receiving the descending woody tissue that is sent into it from the blade, is prolonged inferiorly into a root. The well known fact, that many leaves will readily strike root from the base of their stalk, when used as cuttings, and so form an independent plant, confirms this view, and is not so satisfactorily explicable upon any other.

This primitive individual, or *phyton*, or leaf, has the power of developing a second one, like itself, from the summit of the cauline part; which, by its ascending growth, forms the second joint of stem, and the blade of the second leaf; while, by its descending growth, it can reach the soil only by sending its woody tissues down through the first joint to the same final termination in the root. The second forms a third and similar *phyton* upon its own summit, with its proper leaf; the wood which this generates passing downwardly, penetrating all the preceding *phytons*, and at length reaching the soil in the same manner. Thus the stem results from the evolution of one *phyton* or integral element after another, each developed from, and implanted upon, the summit of its predecessor; — each contributing by its wood to the increase of the common trunk in diameter, and ultimately to the extension of the roots.

The *dicotyledonous embryo* is merely double at the commence-

mutually dependent, that the structure and office of no one of them can be fully explained without presupposing a knowledge of the others. Accordingly, sacrificing somewhat of rigid scientific order to convenience, we have anticipated the leading points of the present chapter.

133. As to the general office of leaves in the vegetable economy, it has been assumed that the leaf is an apparatus in which, under the agency of sun-light, the sap is digested, and converted into the proper nourishment (48) of the plant. As to their situation upon the stem, it has been stated that they invariably arise from the nodes (68), just below the point where buds appear. So that wherever a bud or branch is found a leaf exists, or has existed, either in a perfect or rudimentary state, just beneath it; and buds (and therefore branches), on the other hand, are or may be developed in the axils of all leaves, and do not normally exist in any other situation. And finally, the relation of leaves to the woody system of the stem, as furnishing its

---

ment, or consists of two *phytons*, placed side by side, with their stem-portions united into one body. In other words, it is composed of two original leaves placed side by side, with their stalks united. So, likewise, a polycotyledonous embryo, like that of the Pine, would be deemed to consist of as many original *phytons* as there are cotyledons.

In the progress of embryological research, we may soon be able to test the correctness of the fundamental conception of Gaudichaud's theory, by ascertaining whether the dicotyledonous embryo has really a simpler composition than the monocotyledonous embryo.

As, in the development of the stem, each *phyton* originates in a single vesicle of cellular tissue, the ultimate individuality must be sought in the cell (a view long ago maintained by Turpin); and in the lower Cryptogamous Plants, — such as the Confervas, Charas, Moulds, &c., — buds and branches actually consist of single cells.

materials, has been somewhat particularly noticed in the last chapter. It chiefly remains, therefore, more explicitly to describe their structure.

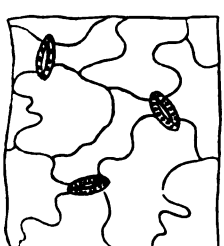
134. The leaf is a contrivance for increasing the green surface of the plant, and exposing to the light and air the greatest practicable amount of the *chlorophylle* (36), the green matter of vegetation, upon which light exerts it peculiar action. Although leaves are termed *appendages of the stem*, it must not be inferred that they are less important organs than the stem itself; for in the offices of foliage the essence of vegetation consists. But, taking the stem as the starting point, the leaf may be rightly viewed as an expansion of its bark, or as a portion of the green envelope (109) pushed outwards, expanded laterally into a thin lamina, and stiffened by tough woody fibres, which are connected both with the liber, or inner bark, and the wood, and which form its frame-work, *ribs*, or *veins*. Like the stem, therefore, the leaf is made up of two distinct parts, the *cellular*, and the *woody*. The cellular portion is the green pulp or parenchyma. The woody, is the skeleton or frame-work on which the green pulp is laid.

135. The woody or fibrous portion fulfils the same purposes in the leaf as in the stem, not only giving firmness and support to the delicate cellular apparatus, but also serving for the conveyance and distribution of the sap. The subdivision of these *veins* of the leaf, as they are not inappropriately called, continues far beyond the limits of unassisted vision, until the bundles or threads of woody tissue are reduced to separate fibres, ramified throughout the green pulp, so as to supply every portion with the sap it consumes.

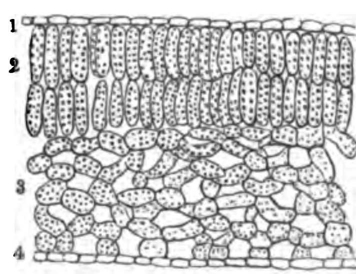
136. The cellular portion, or parenchyma, of the leaf is not a structureless, pulpy mass, such as it appears to the naked eye. The *chlorophylle*, to which the green color is

entirely owing, and which consists of innumerable rounded globules (36), is all inclosed in cells, resembling those of loose cellular tissue in other parts of the plant; and these cells are not heaped promiscuously, but exhibit a regular arrangement; upon a plan, too, which varies in different parts of the leaf, according to the different conditions in which it is placed.

137. Leaves are almost always expanded horizontally, so as to present one surface to the ground and the other to the sky; and the parenchyma forms two general strata, one belonging to the upper and the other to the lower side. The microscope displays a manifest difference in the parenchyma of these two strata. That of the upper stratum is composed of one, two, three, or several compact layers of oblong vesicles of cellular tissue, placed endwise, or with their long diameter perpendicular to the surface; while that of the lower is very loosely arranged, leaving numerous vacant spaces between the cells; and when the cells are oblong, their longer diameter is parallel with the epidermis. This is shown in Fig. 100, from Brongniart, which repre-



101



100

sents a highly magnified view of a thin slice of a leaf of the Garden Balsam, made perpendicular to the surface, so

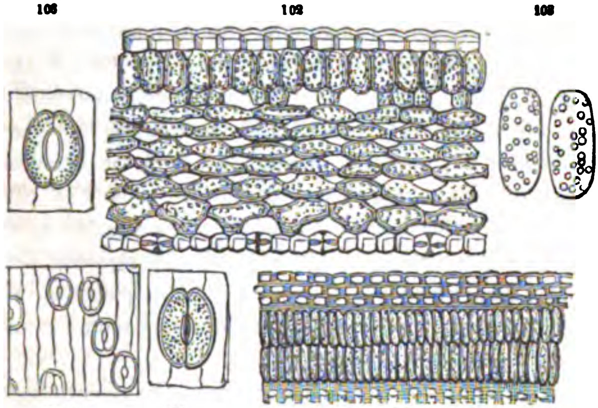
FIG. 100. Magnified perpendicular section of the leaf of the Balsam; and 101, a portion of the epidermis of its lower surface.

that it exhibits the thickness of the leaf; No. 1 represents a section of the epidermis of the upper surface; 2, the upper compact stratum of parenchyma, consisting of two layers of elongated cells, filled with green globules, or *chlorophylle;* 3, the loose parenchyma of the lower stratum; 4, a section of the epidermis of the lower surface. Fig. 101 represents a portion of the epidermis removed from the lower surface. The same arrangement is shown in the more highly magnified view of a section of the leaf of the White Lily (Fig. 102), where the upper stratum is composed of only one compact layer of vertical cells. The parenchyma, or cellular system is alone represented; the woody portion, or veins, being left out.

138. The object of this arrangement will appear evident, when we consider that the spaces between the cells, filled with air, communicate freely with each other throughout the leaf, and also with the external air (by means of holes in the epidermis presently to be described); and when we consider the powerful action of the sun to promote evaporation, especially in dry air, and that the thin walls of the cells, like all vegetable membrane, allow of the free escape of the contained moisture by transudation. The light and air necessarily being freely admitted into the texture of the leaf, the sap it contains would be liable to escape by evaporation faster than it can be supplied from the stem and roots; and the leaf consequently shrivel and perish, just as it speedily does when plucked from the stem. A safeguard against excessive evaporation is to some extent afforded by the more compact arrangement of the upper stratum, which is exposed to the direct action of the sun, as well as by the form and vertical position of these cells, which present the least possible surface to the sun's rays. This provision is the more complete in the case of plants indigenous to hot, arid regions, where the soil is frequently so parched for

long periods as to afford only the scantiest supply of moisture to the roots. Compare, in this respect, the leaf of the Lily (Fig. 102), where the upper stratum contains but a single layer of barely oblong cells, with that of the Oleander, a native of dry and sun-burnt places in the East, the upper stratum of which consists of two layers of very long vertical cells as closely compacted as possible (Fig. 107).

106 102 103



104 105 107

139. A more effectual provision for restraining the perspiration of leaves within due limits is found in the epider-

FIG. 102. Magnified section through the thickness of the leaf of the White Lily, showing the parenchyma, and the epidermis of both surfaces; the lower pierced with stomata. (After Brongniart.) 103. Two of the cells of the upper stratum of parenchyma, detached and more magnified, showing the contained grains of chlorophylle.

FIG. 104. Magnified view of the hundredth part of a square inch of the epidermis of the lower surface, with the stomata, or breathing pores, it bears. These are unusually large in the Lily, so as to be visible by a very moderate magnifying power, and are proportionally few in number. One of them is shown more magnified at 105, in the closed state: and open in 106.

FIG. 107. Magnified perpendicular section through the thickness of epidermis and upper stratum of parenchyma in the leaf of the Oleander (after Brongniart); showing the epidermis composed of three layers of thick-sided cells, and the upper parenchyma of very compact vertical cells.

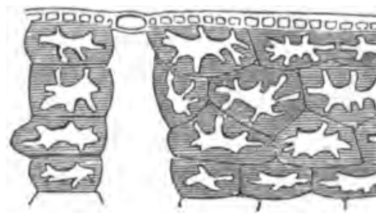
mis, or skin, that invests the leaf, as it does the whole surface of the vegetable, and which is so readily detached from the succulent leaves of such plants as the Stone-crop and the Live-for-ever (Sedum) of the gardens. The epidermis is composed of small cells belonging to the outermost layer of cellular tissue, with the pretty thick-sided walls very strongly coherent, so as to form a firm membrane. Its cells usually contain no chlorophylle (36). In ordinary herbs that allow of copious evaporation, this membrane is made up of a single layer of cells; as in the Lily, Fig. 102, and the Balsam, Fig. 100. It is composed of two layers in cases where one might prove insufficient; and in the Oleander, besides the provision already described, the epidermis consists of three layers of very thick-sided cells (Fig. 107). It is generally thick, or very hard and impermeable in the firm leaves of such house-plants as the Pittosporum, Laurustinus, &c., which will thrive, where other plants are liable to perish, in the dry atmosphere of our rooms at midwinter.

140. In still other cases, the layers of the epidermis are not multiplied, but its walls are greatly thickened and solidified by a secondary deposit (the nature of which has been already described, 23) applied to the interior, especially on the superficial side. This is shown in Fig. 108; a section from the rind of a Cactus. It exists in the Aloe, and other thick-rinded fleshy plants, which are known to sustain severe droughts with impunity.* A somewhat similar deposit likewise occurs in the superficial cells of the paren-

* The pellucid, apparently inorganic membrane that may be detached from the surface of some plants, and which Brongniart and succeeding authors have named the *cuticle*, has been well shown by Mohl to consist of the confluent external parieties of these thickened epidermal cells.

chyma, in many cases, especially in the Cactus tribe (Fig. 108, 109), where the once excessively thin and delicate walls of the cells become excessively and irregularly thickened, so as doubtless to obstruct the exhalation very considerably. Something like this choking of the cells must commonly occur with age in most leaves (192).

108



109

141. But the multiplication of these checks to excessive perspiration might be liable to defeat the very objects for which leaves are principally destined. This evaporation is essential to the plant, as it is the only method by which its excessively dilute food can be concentrated. Some arrangement is requisite that shall allow of sufficient exhalation from the leaves while the plant is freely supplied with moisture by the roots, but restrain it when the supply is deficient. It is clear that the greatest demand is made upon the leaves at the very period when the supply through the roots is most likely to fail: for the summer's sun, which acts so powerfully on the leaves, at the same time parches the soil upon which the leaves (through the rootlets) depend

FIG. 108. Magnified slice of the epidermis and superficial parenchyma of a Cactus, after Schleiden; exhibiting the epidermis greatly thickened by a stratified deposition in the cells: and the cells of the parenchyma likewise nearly filled with an incrusting deposit. The deposition in such cases is always irregular, leaving canals or passages which nearly connect the adjacent cells. Several of the cells contain crystals (37).

FIG. 109. Similar section from another species of Cactus, passing through one of the stomata, and the deep intercellular space beneath it.

for the moisture they exhale. So long as their demands are promptly answered, all goes well. The greater the force of the sun's rays, the greater the speed at which the vegetable machinery is driven. But whenever the supply at the root fails, the foliage begins to flag and droop, as is so often seen under a sultry meridian sun; and if the exhaustion proceeds beyond a certain point, the leaves inevitably wither and perish. Some adaptation is therefore needed, analogous to the governor in machinery, or the self-acting valve, which shall regulate the exhalation according to the supply. There is actually such a provision in the leaves.

142. The epidermis is generally firm enough to prevent the escape of much moisture by direct transudation through its sides; but the exhalation principally takes place through an immense number of holes or slits with which this membrane is perforated. These are called STOMATA, STOMATES, or *breathing-pores* (41, Fig. 101, 104–106). These orifices are situated so as to open directly into the hollow chambers, or air-cavities, which pervade the parenchyma (Fig. 102, 109), especially the lower stratum; so as to afford free communication between the external air and the whole interior of the leaf. The orifice is guarded by two oblong and somewhat salient cells, firmly fixed at their ends, and, unlike the rest of the epidermis, usually containing some chlorophylle. When moist, these hygrometic cells become turgid, and in elongating diverge or curve outwardly in their middle, so as to allow of free communication between the outer air and the interior of the leaf. When dry, they incline to shorten and straighten, so as to bring their sides into contact and close the orifice completely. This structure is sufficiently illustrated by the figures referred to, especially in those of the Lily, where the stomata are unusually large and easy of examination.

The action and use of this mechanism will readily be understood. So long as the leaf is in a moist atmosphere, and is freely supplied with sap by the stem and roots, the cells that guard the orifice are expanded, and the open stomata allow the free escape of moisture by evaporation. But when the supply fails, and the parenchyma begins to be exhausted, the guardian cells, at least equally affected by the dryness, quickly collapse, and by closing these thousands of apertures check the drain the moment it becomes injurious to the plant.

143. As a general rule, the stomata wholly or principally belong to the epidermis of the lower surface of the leaf: * the mechanism is too delicate to work well in direct sunshine. The position of the stomata, and the loose texture of the lower parenchyma require that this surface should be shielded from the sun's too direct and intense action; and show why leaves soon perish when artificially reversed, and prevented from resuming (as they spontaneously will) their natural position.

---

* The number of the stomata varies in different leaves from 800 to about 17,000 on the square inch of surface. In the Apple, there are said to be about 24,000 to the square inch; so that each leaf of that tree would present about 100,000 of these orifices. From their great numbers, they are doubtless fully adequate to the office that is attributed to them, notwithstanding their minute size. Their size varies so greatly in different plants that no safe inference can be drawn of the comparative amount of exhalation in different leaves from the mere number of their stomata. When the stomata are not all restricted to the lower surface, still the greater portion usually occupy this position. Thus the leaf of Arum Dracontium is said to have 8,000 stomata to the square inch of the upper surface, and twice that number in the same space of the lower. The leaf of the Colt's-Foot has 12,000 stomata to a square inch of the lower epidermis, and only 1,200 in the upper.

144. This general arrangement is variously modified under peculiar circumstances. Those leaves of whatever sort which grow in an erect position, or which present their edges, instead of their surfaces, to the earth and sky (167), have the parenchyma of both sides similarly constituted, the stomata equally distributed, and both consequently affect the same relations to light. In the Water-Lilies (Nymphæa, Nuphar), and other leaves which float upon the water, the stomates all belong to the upper surface; and all leaves growing under water, where there can be no evaporation, are destitute not only of stomates, but usually of a distinct epidermis also.

145. Succulent or fleshy plants, such as those of the Cactus tribe, Mesembryanthemums, Sedums, Aloes, &c., are remarkable for allowing very little exhalation, whether on account of the thickness of the epidermis, their comparatively small number of stomata, which are firmly closed in dry air, or from the deposit which early accumulates in the superficial cells of the parenchyma (140, and Fig. 108, 109). Hence their tissue becomes gorged as it were with fluid, which they retain with great avidity, especially during the hot season. They are evidently constructed for enduring severe droughts; and are accordingly found to inhabit dry and sunburnt places, such as the arid, sandy plains of Southern Africa,— the principal home of the Stapelias, Aloes, succulent Euphorbias, &c.,—or the hottest and driest parts of our own continent, to which the whole Cactus tribe is indigenous. Or, when such plants inhabit the cooler temperate regions, like the Sedums and the common Houseleek, &c., they are invariably found in the most arid situations, on naked rocks, old walls, or sterile plains, exposed to the fiercest rays of the noon-day sun, and thriving under conditions which would insure the immediate destruction of ordinary plants. The drier the atmosphere, the greater

their apparent reluctance to part with the fluid they have accumulated, and upon which they live during the long period when little or no moisture is yielded by the soil or the air. Their structure and economy fully explain their tolerance of the hot and very dry air of our houses in mid-winter, when ordinary thin-leaved plants become unhealthy or perish.

146. Sometimes the leaves of succulent plants merely become obese or misshapen, like those of the Houseleek, Ice-plant, &c.: sometimes they are reduced to triangular projections or points, or are perfectly confounded with the unusually developed green bark of the stem, which fulfils their office, as in the Stapelia and Cactus.

§ 2. Their External Conformation.

147. The forms which leaves assume in different species are almost infinitely various. These afford some of the readiest, if not the most certain marks for distinguishing and characterizing species. Their principal modifications are therefore classified, minutely defined, and embodied in a system of nomenclature which is equally applicable to other parts of the plant, and which as an instrument is indispensable to the systematic botanist. The vast number of entirely unconnected technical terms which have gradually accumulated from the infancy of the science, and have multiplied with its increasing wants, are mostly quite arbitrary, or have been suggested by real or fancied resemblances of their shapes to natural or other objects. This arbitrary nomenclature, which formerly severely tasked the memory of the student, was reduced by De Candolle into a clear and consistent system, based upon scientific principles, and of easy application. The fundamental idea of the plan is, that the almost infinite varieties in the form and

outline of leaves may be deduced from the different modes and degrees in which the woody skeleton or framework of the leaf is expanded or ramified in the parenchyma.* Upon this conception our following sketch is based; in which we endeavour to introduce and define the more important terms of the nomenclature of leaves.

148. The leaf is commonly raised on an unexpanded part, or stalk, which is called the PETIOLE; while the expanded surface is termed the LAMINA, LIMB, or BLADE. When the vessels and fibres of the leaves expand immediately on leaving the stem, the petiole of course is wanting, and the leaf is said to be *sessile*. The portion of the blade next the stem is called the *base;* its opposite extremity, the *apex*. When the blade consists of a single piece, however incised or cut, it is said to be *simple* (Fig. 110 – 131): but when composed of two, or any number of separate portions, or smaller blades, or in other words, when the petiole is branched, the leaf is said to be *compound* (Fig. 133, 137 – 143). There are, however, so many transitions between these two kinds, that they cannot be very absolutely distinguished. But the separate blades, or *leaflets*, of a truly compound leaf, are generally *articulated* (or jointed) with the main petiole, and fall off separately, just as the petiole separates from the stem; while the divisions of a simple leaf, however deep they may be, are never detached separately. This distinction is the more worthy of notice, since the two forms very rarely coexist in the same genus, and seldom in the same natural group; but such cases do occasionally occur, and in many others it is not easy to ascertain whether the leaflets are articulated or not.

* Original as this idea doubtless was with De Candolle, yet it had already been distinctly propounded by Goethe. Vid. *Metamorph. Pl.*, the French translation by Martins, p. 215.

149. The distribution of the veins or framework of the leaf in the blade, is termed *venation*. The veins are distributed throughout the lamina in two principal modes. Either the vessels of the petiole divide at once, where they enter the blade, into several veins which run parallel with each other to the apex, connected only by simple transverse veinlets (as in Fig. 117, 123); or the petiole is continued into the blade in the form of one or more principal or coarser veins, which send off branches on both sides, the smaller branchlets uniting with one another (*anastomosing*) and forming a kind of network; as in Fig. 113, 121, &c. The former are termed *parallel-veined*, or commonly *nerved* leaves; the veins in this case having been called nerves by the older botanists; a name which it is found convenient to retain, improper as it is, since the veins are in no respect analogous to the nerves of animals. The latter are termed *reticulated* or *netted-veined* leaves.

150. Parallel-veined or nerved leaves are characteristic of Endogenous Plants; while reticulated leaves are almost universal in Exogenous Plants. We are thus furnished with a very obvious, although not entirely absolute distinction between these two great classes of plants, independently of the structure of their stems (100).

151. In reticulated leaves, the coarse primary veins (one or more in number), which proceed immediately from the apex of the petiole, are called *ribs;* the branches are termed *veins*, and their subordinate ramifications, *veinlets.* Very frequently, a single strong rib (called the *midrib*), forming a continuation of the petiole, runs directly through the middle of the blade to the apex (Fig. 118, 119, &c.), and from it the lateral veins all diverge. Such leaves are termed *feather-veined;* and are subject to various modifications, according to the arrangement of the veins and veinlets; the primary veins sometimes passing straight from the

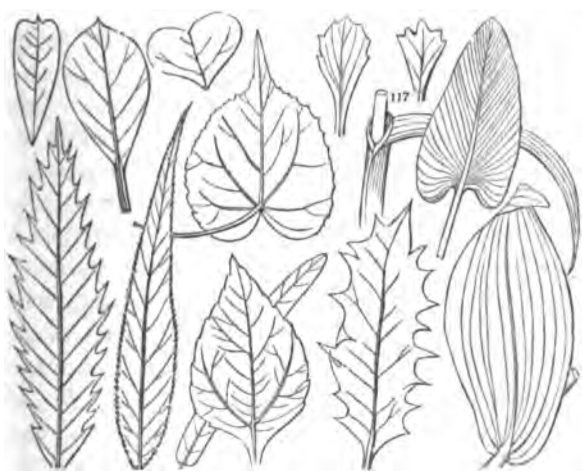
midrib to the margin, as in the Beech and Chestnut (Fig. 118); while in other cases they are divided into veinlets long before they reach the margin. When the midrib gives off a very strong primary vein or branch on each side above the base, the leaf is said to be *triple-ribbed*, or often *tripli-nerved;* as in the common Sunflower (Fig. 121); if two such ribs proceed from each side of the midrib, it is said to be *quintuple-ribbed*, or *quintupli-nerved.*

152. Not unfrequently the vessels of a reticulated leaf divide at the apex of the petiole into three or more portions or ribs of nearly equal size, which are usually divergent, each giving off veins and veinlets, like the single rib of a feather-veined leaf. Such leaves are termed *radiated-veined*, or *palmately-veined;* and, as to the number of the ribs, are called three-ribbed, five-ribbed, seven-ribbed, &c. (Fig. 113, 125, 131). Examples of this form are furnished by the Maple (Fig. 499), the Gooseberry (Fig. 586), the Mallows tribe, &c. Occasionally the ribs of a radiated-veined leaf converge and run to the apex of the blade, as in Rhexia, and other plants of the same family; thus resembling a parallel-veined or nerved leaf; from which, however, it is distinguished by the intermediate netted veins. But when the ribs are not very strong, such leaves are frequently said to be nerved, although they branch before reaching the apex.

153. The form of leaves may be considered to depend upon the distribution of the veins, and the quantity of parenchyma. The general outline is determined by the division and direction of the veins; and the form of the margin, (whether even and continuous, or interrupted by void spaces or indentations,) by the greater or less abundance of the parenchyma in which the veins are distributed. This is readily intelligible upon the supposition that a leaf is an expansion of soft cellular tissue, in which the firmer veins are variously ramified.

154. If the principal veins of a feather-veined leaf are not greatly prolonged, and are somewhat equal in length, the blade will have a more or less elongated form. If the veins are very short in proportion to the midrib and equal in length, the leaf will be *linear* (as in Fig. 120); if longer in proportion, but still equal, the leaf will assume an *oblong* form. If the veins in the middle of the blade are somewhat more extended, an *oval* or *elliptical* outline will be

110 111 112 113 114 115 116

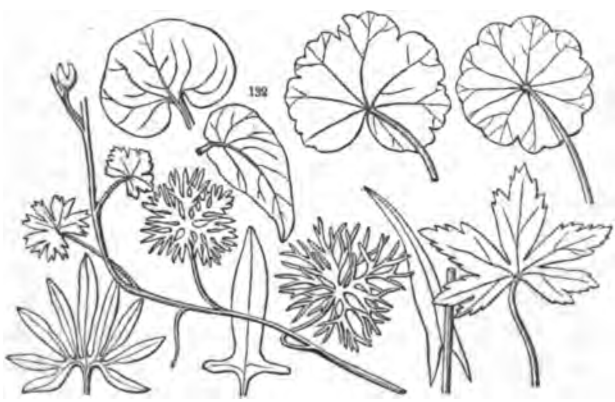


118 119 120 121 122 123

produced. If the veins next the base are longest, and especially if they curve forward towards their extremities, the leaf assumes a *lanceolate* (Fig. 119), *ovate* (Fig. 121), or some intermediate form. On the other hand, if the veins are more developed beyond the middle of the blade, the leaf becomes *obovate* (Fig. 111), or *cuneiform* (Fig. 115). In radiated or palmately-veined leaves (Fig. 124 – 126), where the primary ribs are divergent, an orbicular or

FIG. 110 – 123. Various forms of simple leaves.

roundish outline is most common, and indeed is universal when the ribs are of equal strength. Some of the ribs or their ramifications being directed backwards, a recess, or *sinus*, as it is termed, is produced at the base of the leaf, which, taken in connection with the general form, gives rise to such terms as *cordate* or *heart-shaped* (Fig. 113), *reniform* or *kidney-shaped* (Fig. 124), &c., where the posterior portions are rounded; and those of *sagittate* or *arrow-headed* (Fig. 130), and *hastate* or *halberd-shaped* (Fig. 128),



when they are produced into angles or lobes. The margins of the sinus are sometimes brought into contact, or overlap each other, when they are frequently united; for it may be remarked, that whenever soft cellular parts are in close contact at an early period of their development, they are very apt to cohere and grow together. In this case the leaf becomes *peltate*, or *shield-shaped* (as in Brasenia, Fig. 383); the blade being attached to the petiole, not by its apparent base, but by some part of the lower surface. Two or three

FIG. 124-132. Forms of simple, chiefly radiated-veined leaves.

common species of Hydrocotyle plainly exhibit the transition from common radiated leaves into the peltate form. Thus, the leaf of H. Americana (Fig. 125) is roundish-reniform, with an open sinus at the base; while in H. interrupta and H. umbellata (Fig. 126), the margins have grown together so as to obliterate the sinus, and an orbicular peltate leaf is produced. In nerved leaves, when the nerves run parallel from the base to the apex, as in Grasses, the leaf is necessarily linear, or nearly so; but when they are more divergent in the middle, or towards the base, the leaf becomes oblong, oval, or ovate, &c. (Fig. 123). In one class of nerved or parallel-veined leaves, the simple veins or nerves arise from a prolongation of the petiole in the form of a thickened midrib, instead of the base of the blade, constituting the *curvinerved* leaves of De Candolle. This structure is almost universal in the Ginger tribe, the Arrow-root tribe, in the Banana, and other tropical plants, and our common Pontederia, or Pickerel-Weed (Fig. 116), affords an illustration of it; in which the nerves are curved backwards at the base, so as to produce a cordate outline.

155. When the parenchyma is fully developed to the same degree as the framework, or veins, the interstices between the latter being perfectly filled, the margin is of course continuous and even, or, in botanical language, *entire*. But when the spreading veins are more extended, and the parenchyma less abundant, the latter, we may suppose, is insufficient completely to fill up the framework; and consequently *lobes*, *incisions*, or *toothings* are produced, extending from the margin towards the centre; or, in rare cases, holes are left in the middle of the leaf. In the White and the Yellow species of Water Ranunculus, there appears to be barely sufficient parenchyma to form a thin covering for each vein and its branches (Fig. 129, the lowest leaf); such leaves are said to be *filiformly dissected*, that is, *cut*

into threads; the nomenclature in all these cases being founded on the convenient, but incorrect supposition, that a leaf originally entire is cut into teeth, lobes, divisions, &c. If, while the framework remains the same as in the last instance, the parenchyma be more abundantly developed, as in fact happens in the upper leaves of the same species when they grow out of water, they are merely *cleft* or *lobed.* If these *lobes* grow together nearly to the extremity of the principal veins, the leaf is only *toothed*, *serrated*, or *crenated;* and if the small remaining notches were filled with parenchyma the leaf would be *entire.* We may now proceed to explain the principal terms which designate the degree or the mode of division in simple leaves, without further reference to the theory by which such diversities are explained.

156. A leaf is said to be *serrate*, when the margin is beset with sharp teeth which point forwards towards the apex (Fig. 118); *dentate*, or *toothed*, when the sharp salient teeth are not directed towards the apex of the leaf (Fig. 122); and *crenate*, when the teeth are rounded (Fig. 125, 126). A slightly waved or sinuous margin is said to be *repand;* a strongly uneven margin, with alternate rounded concavities and convexities, is termed *sinuate* (as in the Oak, Fig. 927). When the leaf is irregularly and sharply cut deep into the lamina, it is said to be *incised;* when the portions, or *segments*, are more definite, it is said to be lobed; and the terms, *two-lobed*, *three-lobed*, *five-lobed*, &c., express the number of the segments. If the incisions extend about to the middle of the blade, or somewhat deeper, the leaf is said to be *cleft;* and the terms *two-cleft*, *three-cleft*, &c. (or in the Latin form, *bifid*, *trifid*, &c.) designate the number of the segments: or when the latter are numerous or indefinite, the leaf is termed *many-cleft*, or *multifid.* If the segments extend nearly, but not quite, to the base of the

blade or the midrib, the leaf is said to be *parted* (Fig. 131): if they reach the midrib or the base, so as to interrupt the parenchyma, the leaf is said to be *divided;* the number of *partitions* or *divisions* being designated, as before, by the terms *two*, *three*, *five-parted*, or *two*, *three*, *five-divided*, &c. The latter form differs from a compound leaf only in not having the several portions articulated with the petiole or midrib.

157. As the mode of division depends upon the arrangement of the primary veins, the lobes or incisions of feather-veined are differently arranged from those of radiated or palmately veined leaves: in the latter, the principal incisions are all directed to the base of the leaf; in the former, they extend towards the midrib. These modifications are accurately described by terms indicative of the venation, combined with those that express the degree of division. Thus, a feather-veined (in the Latin form, a *pinnately veined*) leaf is said to be *pinnately cleft* or *pinnatifid*, when the sinuses reach half way to the midrib; *pinnately parted*, when they extend almost to the midrib (as in Fig. 766); and *pinnately divided*, when they reach the midrib, dividing the parenchyma into separate portions. A few subordinate modifications are indicated by special terms: thus a pinnatifid or pinnately parted leaf, with regular, very close and narrow divisions, like the teeth of a comb, is said to be *pectinate* (as in Proserpinaca pectinacea); a feather-veined leaf, more or less pinnatifid, but with the lobes decreasing in size towards the base, is termed *lyrate*, or *lyre-shaped* (Fig. 134); and a lyrate leaf with sharp lobes pointing towards the base, as in the Dandelion (Fig. 135), is called *runcinate*. A palmately-veined leaf is in like manner said to be *palmately cleft*, *palmately parted*, *palmately divided*, &c. (Fig. 129, 131), according to the degree of division. The term *palmate* was originally employed to designate a leaf more or less deeply cut into about five

spreading lobes, bearing some resemblance to a hand with the fingers spreading; and it is still used to designate a palmately lobed leaf, without reference to the depth of the sinuses. A palmate leaf with the lateral lobes cleft into two or more segments, is said to be *pedate* (Fig. 127), from a fancied resemblance to a bird's foot. By designating the number of the lobes in connection with the terms which indicate their extent and their disposition, botanists are enabled to describe all these modifications with great brevity and precision. Thus, a *palmately five-parted* leaf is one of the radiated-veined kind, which is divided almost to the base into five segments: a *pinnately five-parted* leaf, is one of the feather-veined kind cut into five lobes (two on each side, and one terminal), with the sinuses extending almost to the midrib: and the same plan is followed in describing cleft, lobed, or divided leaves.

158. The segments of a lobed or divided leaf may be again divided, lobed, or cleft, upon the same principle as the leaf itself, and the same terms are employed in describing them. Sometimes both the primary, secondary, and even tertiary divisions are defined by a single word or phrase; as *bipinnatifid* (Fig. 136), *tripinnatifid*, *bipinnately parted*, *tripinnately parted*, *twice palmately parted*, &c. &c.

159. In accordance with the theory we have illustrated, truly parallel-veined or nerved leaves may be expected to present entire margins, and this in fact almost universally occurs when the nerves are convergent (Fig. 123, 116). Such leaves are often lobed or cleft when the principal nerves diverge greatly, but the lobes themselves are entire. So, also, ribbed leaves are mostly entire, when the ribs converge to the apex: and leaves which exhibit a well-marked marginal vein (the *falsely ribbed* leaves of Lindley), into which the lateral veinlets are confluent (as in all Myrtaceous Plants), are universally entire. This is beautifully illustrated

by the marginal-veined leaves of Andromeda (Leucothoe) coriacea, which are always entire; while those of the allied Andromeda axillaris, which want this marginal vein, are sharply serrated.

160. There are a few terms employed in describing the apex of a leaf, which may be here enumerated. When a leaf terminates in an acute angle, it is said to be *acute* (Fig. 121, 123): when the apex is an obtuse angle, or rounded, it is termed *obtuse* (Fig. 116, 120): an obtuse leaf, with the apex slightly indented or depressed in the middle, is said to be *retuse*, or if more strongly notched, *emarginate* (Fig. 110): an obovate leaf with a wider and more conspicuous notch at the apex is termed *obcordate* (Fig. 112), being a cordate or heart-shaped leaf inverted. When the apex is, as it were, cut off by a straight transverse line, the leaf is said to be *truncate:* when abruptly terminated by a small projecting point, it is *mucronate* (Fig. 110, 111): and when an acute leaf has a narrowed and prolonged apex, it is *acuminate*, as in Fig. 113.

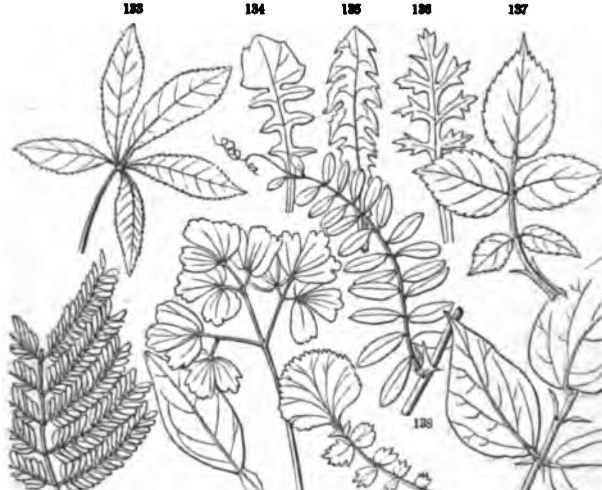
161. These and similar terms are applicable to all expanded surfaces (such as petals, sepals, &c.), as well as to leaves.

162. COMPOUND LEAVES (Fig. 137 – 143) are the same as divided simple leaves, except that the divisions (called LEAFLETS), usually supported by separate stalks, are articulated with the main or common petiole, and fall away separately. Their modifications will therefore be readily apprehended, if the mode of division and veining of simple leaves be kept in view.

163. When a feather-veined leaf becomes compound, a *pinnate* leaf is produced (Fig. 137, 138); which again divided, or doubly compound, becomes *bipinnate* (Fig. 139); if a third time divided, or triply compound, it is *tripinnate*, &c. As to the disposition of the leaflets, such a leaf is

said to be *abruptly pinnate*, when, the leaflets being even in number, none is borne on the very apex of the petiole or its branches (as in Cassia); and *impari-pinnate*, or pinnate with an odd leaflet, when the petiole is terminated with a leaflet (Fig. 137, 142). The number of leaflets varies from very numerous, as in many species of Acacia, Mimosa, &c., to very few. When reduced to a small number, such a leaf is said to be *pinnately seven*, *five*, or *tri-foliolate*, as the case may be. A pinnate leaf of three or five leaflets is often called *ternate*, or *quinate;* which terms, however, are equally applied to a palmately compound leaf, and also, and more appropriately, to the case of three or five simple leaves growing on the same node. A *pinnately tri-foliolate* leaf (Fig. 143), is readily distinguished by having the two

133 134 135 136 137



139 140 141 142 143

lateral leaflets attached to the petiole at some distance below its apex, and by the joint which is observable at some

FIG. 133-143. Compound and lobed leaves.

point between their insertion and the lamina of the terminal leaflet. Such a leaf may even be reduced to a single leaflet, as in the Orange (Fig. 140), and frequently in one variety of Rhynchosia tomentosa; when it is distinguished from a really simple leaf by the joint at the junction of the partial with the general petiole. When a palmately-veined leaf becomes compound, the leaflets are necessarily all attached to the apex of the common petiole, forming a *digitate* leaf, as in the Horse-Chestnut and Buckeye (Fig. 133). Such a leaf may be again compounded in the same manner; as in the *biternate* (Fig. 141), or *triternate* leaves of Isopyrum, Thalictrum, Aquilegia, &c. But, since the secondary veins of a palmately compound leaf are commonly pinnate, the secondary, or at least the ultimate divisions of a digitate leaf are consequently often pinnate, as is frequently observed in the Mimosa tribe. Digitate leaves of three, five, or any definite number of leaflets are termed *palmately* (or *digitately*) *tri-foliolate*, *five-foliolate*, &c. By this nomenclature, the distinction between digitate and pinnate leaves is readily apprehended.

164. Leaflets present all the diversities of form, outline, or division, which simple leaves exhibit; and the same terms are employed in characterizing them.

165. The blade of a leaf is commonly symmetrical, that is, the portions on each side of the midrib or axis are similar; but occasionally one side is more developed than the other, when the leaf is *oblique*, as is strikingly the case in the species of Begonia (Fig. 132), now common in gardens.

166. The blade is also commonly horizontal, presenting one surface to the sky, and the other to the earth; in which case the two surfaces differ in structure (137) as well as in appearance, each being fitted for its peculiar offices: hence, if artificially reversed, they resume their natural

position, or soon perish if prevented from doing so. But in erect or vertical leaves, the two surfaces are equally exposed to the light, and are similar in structure and appearance. In such erect leaves as those of Iris (Fig. 1013), it is what corresponds to the lower surface of ordinary leaves that is presented to the air; for the leaf is folded together lengthwise and consolidated while in the nascent state, so that the true upper surface is concealed in the interior, except near the base, where the union is generally imperfect. Such leaves are said to be *equitant*.

167. True vertical leaves, which present their edges instead of their surfaces to the earth and sky, generally assume this position by a twisting of the base or of the petiole; as is strikingly seen in a large number of New Holland trees of the Myrtle family, now common in greenhouses.*

168. The ordinary appearance of leaves is greatly changed when they become *succulent*, as in the different species of Mesembryanthemum (Ice-Plant), &c., assuming various unusual shapes, and exhibiting no obvious distinction of surfaces. In such cases, the veins are entirely hidden in the superabundant parenchyma, as in some others they are concealed by the thickened and opaque epidermis. But where, on the contrary, leaves produce no green pulp, they may become scale-like, as in Orobanche (Fig. 719), Monotropa (Fig. 682), and other parasitic plants; when they do not perform the ordinary office of leaves.

169. Leaves which grow under water are often nearly or quite destitute of parenchyma; as in Ranunculus Purshii (Fig. 129), and Ranunculus aquatilis, Bidens Beckii, Myriophyllum, &c. A very remarkable instance of the kind

* Also in Sericocarpus tortifolius, Boltonia, and other of our Compositæ.

occurs in Ouvirandra fenestralis, a South African aquatic plant, with nerved leaves, which exhibit a complete framework or skeleton, while the parenchyma is entirely wanting. Sometimes they harden into spines, as in the Barberry (Fig. 374).

170. When the blade of the leaf is wanting, its office is sometimes performed by the petiole, or by the stipules.

171. The PETIOLE is usually either round, or half-cylindrical and channelled on the upper side. But in the Poplar, it is strongly flattened at right angles with the blade, so that the slightest breath of air puts the leaves in motion. It is not unfequently furnished with a leaf-like border, or wing; which, in the Sweet Pea of the gardens, extends along the stem. In many Umbelliferous plants, the base of the petiole is dilated into a broad and membranaceous inflated sheath; and in a great number of Endogenous plants, especially in Grasses, the petiole consists of a *sheath*, embracing the stem, which in the true Grasses is furnished at the summit with a membranous appendage called the *ligule* (Fig. 117). In the Pea tribe, the apex of the petiole is often changed into a tendril (Vicia, Fig. 138, &c., Lathyrus, Fig. 530); and in Lathyrus Aphaca, the whole petiole becomes a tendril, the office of the leaf being fulfilled by a pair of large stipules. In one section of Astragalus, the petioles harden into spines after the leaflets fall off.

172. In some plants, especially the Australian Acacias, the lamina of the leaf is abortive, and the petiole is dilated into a kind of nerved leaf, called a *phyllodium* (Fig. 147); which is distinguished from a true lamina by being entire and nerved, while the real leaves of the genera in which phyllodia occur are usually compound and netted-veined. They are also recognized by their truly vertical position, presenting their margins instead of their surfaces to the earth and sky; and they sometimes bear a true compound

lamina at the apex, as in Fig. 148. These Acacias, with the Myrtaceous trees that have true vertical leaves (167), compose more than half of the forests of New Holland, and give to them a prevailing and very peculiar feature, and a singular distribution of light and shade; the cause of which was detected by the scrutinizing glance of Robert Brown.

173. The curious and highly sensitive lamina of the leaf of Dionæa muscipula or Venus's Fly-Catcher (Fig. 437), is borne on a dilated and leaf-like petiole, which probably fulfils the ordinary office of the leaf.

174. Several plants, of different families, bear *pitchers*, or *ascidia*, in the place of leaves; which are commonly transformed petioles. If we conceive the margins of the dilated petiole of Dionæa to curve inwards until they meet, and cohere with each other, there would result a leaf very like that of Sarracenia purpurea (Fig. 145), in which, accordingly, the tube or pitcher is considered as the petiole,

FIG. 144. Pitchers of Heliamphora; 145, of Sarracenia purpurea; 146. of Nepenthes. 147. A phyllodium of a New Holland Acacia. 148. The same, bearing a reduced compound lamina.

and the hood at the summit as the lamina. This view is confirmed by a new Pitcher-plant of the same family (Heliamphora, Fig. 144), recently discovered by Mr. Schomburgk in the mountains of British Guiana, and described by Mr. Bentham; in which the margins of the dilated petiole are not always united quite to the summit; and the lamina is represented by a small concave terminal appendage. In the curious Nepenthes (Fig. 146), the petiole is first dilated into a kind of lamina, then contracted into a tendril, and finally dilated into a pitcher, containing fluid secreted by the plant itself; the orifice being accurately closed by a lid, which is from analogy supposed to represent the lamina.

175. The cohesion of the edges of a leaf with each other, or with neighbouring organs, is by no means infrequent; since all parts or organs of a plant which are contiguous at the time of their development are liable to become ingrafted or to cohere together. This is illustrated by the formation of peltate leaves (154), and by what are termed *perfoliate* leaves; whether formed by the union of the bases of a pair of opposite sessile leaves (*connate-perfoliate*), as in Silphium perfoliatum, Triosteum perfoliatum, many species of Honeysuckle (Fig. 623), &c.; or consisting of a single clasping leaf, the posterior lobes of which encompass the stem and cohere on the opposite side, as in Bupleurum rotundifolium, Uvularia perfoliata, and Baptisia perfoliata (Fig. 149).


149

FIG. 149. Perfoliate leaves of a species of Baptisia.

§ 3. Of their lateral Appendages, called Stipules.

176. Stipules are appendages of leaves, usually in the form of small leaf-like bodies, situated on each side of the base of the petiole (Fig. 138, &c.). They are not found in the greater number of plants; but their presence or absence is commonly uniform throughout each natural order. They usually have the texture, color, and venation of leaves, are subject to all the ordinary modifications of the latter, and are said occasionally to produce leaf-buds in their axils. Like leaves, they are sometimes membranaceous or scale-like, and sometimes transformed into spines, &c.; and they have also a strong tendency to cohere with each other, or with the base of the petiole. Thus, in the Clover, the Strawberry (Fig. 556), and the Rose (Fig. 137), a stipule adheres to each side of the base of the petiole; in the Platanus or Plane-tree, they are free from the petiole, but cohere by their outer margins, so as to form an apparently single stipule opposite the leaf. In other cases, both margins are united, forming a sheath around the stem, just above the leaf: these are called *intrafoliaceous* stipules, or, when membranaceous, as in Polygonum (Fig. 861), they receive the name of *ochreæ*. When opposite leaves have stipules, which is not very common, they usually occupy the space between the petioles on each side, and are termed *interpetiolar*. The stipules of each leaf (one on each side) being thus placed in contact, frequently unite, so as to form apparently but a single pair of stipules for each pair of leaves; instances of which are very common in the order Rubiaceæ (Fig. 632).

177. When leaves are furnished with stipules, they are said to be *stipulate:* when destitute of these appendages, *exstipulate.* They are sometimes present in young leaves,

but soon fall off; as in the Fig, and the Magnolia tribe, where the convolute stipules form the covering of the buds, but fall away as these expand.

178. The leaflets of compound leaves are sometimes provided with small stipules (*stipelles*); as in the Bean (Fig. 143); when they are said to be *stipellate*.

§ 4. Of their Arrangement.

179. The point of attachment of a leaf (or other organ) with the stem is termed its *insertion;* an expression which, like many others in the language of botany, must be taken to represent the appearance only, and not the literal fact. For leaves are not *inserted* into the stem, but grow out of it, and petals are not *inserted* into the calyx, as the language used in description literally imports, but are *adherent to the calyx*, &c.

180. As regards their position on the stem, leaves are said to be *radical*, when they are *inserted* into the stem at or below the surface of the ground, so as apparently to grow from the root, as those of the Primrose (Fig. 692), and of the acaulescent Violets (Fig. 424); those that arise along the main stem are termed *cauline;* such as belong to the branches, *rameal;* and those which stand upon or at the base of flower-branches are called *floral;* the latter, however, are generally termed *bracts*.

181. With respect to succession, those leaves which manifestly exist in the embryo are called *seminal;* the first or original pair receiving the name of *cotyledons*, and usually differing widely in appearance from the *ordinary* leaves which succeed them. The earliest ordinary leaves, termed *primordial*, as well as the cotyledons, usually perish as soon as others arise to supply their place.

182. As to their situation with respect to each other,

leaves are *alternate*, when they arise one above another at regular distances around the stem (Fig. 149, 927, &c.); *opposite*, when placed in pairs on opposite sides of the stem (as in Fig. 446, 452, &c.); and *verticillate*, or *whorled*, when more than a single pair arise from the same node, forming a *whorl* or *verticil* around the stem; as in Cornus Canadensis (Fig. 619), the Madder (Fig. 627).

183. The case of alternate leaves is the simplest and the most common. Alternate leaves are seldom placed one above the other on exactly opposite points of the stem; but the second leaf will be found to arise a little to the right or left of the opposite point, and the third a little on one side of the perpendicular to the first; so that, in the Apple and Pear-tree, it is only when we reach the sixth leaf that we find one placed exactly over any of the five preceding. The sixth, in this instance, is found to be inserted directly over the first, the seventh over the second, the eighth over the third, and so on. The leaves are therefore disposed in series or *cycles* of fives, and so arranged that, if we trace a line connecting their bases, a simple spiral will be formed, making two turns around the stem for each cycle, along which the leaves are regularly and equably distributed. This spiral arrangement of the leaves, variously modified in different plants but remarkably constant in the same species, is of general, if not universal, occurrence. The particular mode just described, namely, in cycles of five, is the prevalent one in Exogenous plants, but other combinations are not unusual. In the Linden we have the spire reduced to the very simplest state, where the leaves are alternately situated on exactly opposite sides of the stem, so that the third leaf is placed over the first, completing the first spire and commencing the second. This two-ranked or *distichous* arrangement is most conspicuous in Iris (Fig. 1013) and many other Endogens; but the three-ranked or

tristichous arrangement is probably the most frequent in the Endogenous class. The spiral disposition is most apparent when the leaves are close; as in the Pine, the Pine-Apple, the Pandanus (Fig. 63), called Screw-Pine on this account, &c.; although in such cases the arrangement is less simple than in those which we have taken for illustration.

184. The manner in which the spiral arrangement secures the equable distribution of the foliage of a branch may be seen by projecting the spires in a given case, and marking the position of the leaves on a horizontal plan; or by direct observation when the leaves are naturally approximated, as in the Umbrella-tree (Magnolia Umbrella), and the *rosettes* of the House-leek, &c. Its usefulness in producing the equable deposition of wood over the whole circumference may be inferred from what has already been stated as to the action of leaves in this respect (127), and from the angular shoots of many opposite-leaved plants, or the flattened and two-edged stems which are apt to accompany the distichous arrangement. The light that it throws upon the structure of the flower will be alluded to in the proper place. It may here be barely remarked, that the spiral arrangement extends to all parts which are modifications of leaves, and is very apparent in the scales of the cones of Pines and Firs, Fig. 956 (the true nature of which will hereafter be explained), in which the arrangement varies in different species. The mathematical properties and laws of these spires have recently been investigated with great care and minuteness; but the details of *phyllotaxis* are somewhat recondite, and do not appear to afford obvious applications of importance to structural or systematic botany.

185. The pairs of opposite leaves follow the spiral arrangement, in some of its modifications, and may be con-

ceived either to consist of two spirals proceeding simultaneously up the stem, or to arise from the non-development or great abbreviation of the alternate internodes. So a *verticil* or *whorl* of leaves may be considered to arise from the non-development of the internodes of a complete cycle; and, instead of a single continuous spiral, we have a series of superposed circles. If we follow the corresponding leaves of successive verticils, we find them in rare cases directly superposed; more commonly with the alternate verticils superposed, the leaves of one verticil being placed exactly over the middle of the intervals of that next below. In the latter case, if the whorls consist of only one pair of leaves, or, in other words, if the leaves are simply opposite, the pairs will cross each other at right angles. The leaves, in such case, are said to be *decussate*, and will exhibit four rectilinear series (as in the whole Mint tribe); if in verticils of three, there will be six series, &c. Where the pairs do not cross each other exactly at right angles, several will intervene before there is an exact superposition; the pairs following a similar spiral arrangement to that most common in alternate leaves. If, therefore, we conceive the *normal* or typical arrangement of leaves to be spirally alternate, as many authors assume, a whorl is to be considered as arising from the elongation of the stem being from time to time suspended during the formation of a spire of leaves; so that the node of a whorl consists of as many separate nodes as there are leaves in it; and opposite leaves may be viewed as whorls reduced to a single pair. But if, as some authors suppose, leaves are normally in whorls upon the nodes, then the spirally alternate arrangement is deemed to originate from the breaking up of these nodes by the upward force which produces the elongation of the stem, acting in a spiral direction; and consequently it is only when the nodes are so constituted as to resist this elongating

force, or when the latter is diminished or suspended, that the leaves may be supposed to retain their opposite or whorled arrangement.

186. The opposition or alternation of the leaves is generally constant in the same species; yet the transition from opposite to alternate leaves upon the same stem is not very rare; it often occurs in the common Myrtle, the Snapdragon, and on the branches of some other opposite-leaved plants that are rapidly elongating. All Exogens, having their cotyledons or embryo-leaves opposite (100), necessarily commence with that mode; many retain it throughout; others change to alternation, either directly in the primordial leaves, or at a later period. In Endogens, on the contrary, the first leaves are necessarily alternate (444), and it is very seldom that they afterwards exhibit opposite or whorled leaves.

187. Only one leaf arises from the same organic point. What are called *fascicled* or *tufted* leaves are merely those of an axillary branch, which is so short that the bases of the leaves are in contact. This is plainly seen in the Barberry (Fig. 375), where the primary leaves, hardening into a kind of thorn, the bud in its axil developes into a branch with very slight elongation of the internodes. Of the same nature are the fascicled leaves of the Piue, and, more evidently, of the Larch (Fig. 150), where the whole foliage of the branch is developed without any elongation of the axis.

150

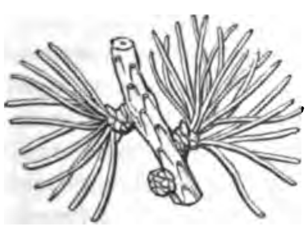


FIG. 150. Clustered or fascicled leaves of the Larch.

§ 5. Their Vernation or Præfoliation.

188. The manner in which the unexpanded leaves are folded or packed together in the bud is distinguished by the name of the *vernation* or *præfoliation*. The terms employed to characterize the different modes, however, are not peculiar, and scarcely require to be enumerated. The principal forms of vernation are, 1st, the *appressed*, when the unexpanded leaves are flat, and applied to each other in pairs, face to face, a good example of which occurs in the stipules of Liriodendron, or the Tulip-tree; 2d, the *opposite*, when they are placed in successive pairs at right angles to each other, and half-folded, so that the outer pairs inclose the inner, as in the Lilac; 3d, the *equitant*, when alternate leaves are infolded lengthwise and opposite each other, the outer inclosing the inner; 4th, the *half-equitant*, or *obvolute*, when one of the margins of each leaf is exterior, the other interior, as in the Sage; 5th, the *conduplicate*, when each leaf is infolded longitudinally upon itself, as in the Linden or Basswood; 6th, the *plicate*, or *plaited*, when each leaf is several times folded, like the plaits of a closed fan, as in the Vine; 7th, the *involute*, when the edges are spirally rolled inwards, as in the Violet, and in Brasenia (Fig. 383); 8th, the *revolute*, when the edges are rolled outwards or backwards, as in the Rosemary, and in many Willows; 9th, the *convolute*, when the leaf is spirally rolled up from one of its edges, as in the cultivated Cherry; and 10th, the *circinate*, when it is spirally rolled up from the apex downwards, as in the Drosera or Sundew,—a mode which prevails in Ferns (Fig. 286).

§ 6. The Death and Fall of the Leaves; Exhalation and its Consequences.

189. In view of their duration, leaves are called *fugacious*, when they fall off soon after their first appearance; *deciduous*, when they last for a single season, and fall in autumn; and *persistent*, when they remain through the cold season and until after the appearance of new leaves, so that the stem is never leafless: plants bearing leaves of this last named sort are called *Evergreens*.

190. Leaves usually exist but for a single year. Most Evergreens are scarcely exceptions, as their old leaves commonly fall, or at least become inactive, soon after those of the ensuing season are developed. Yet in some cases (as in Firs, &c.) they do survive for a series of years. On the other hand, it is seldom that all the leaves of an herb endure through the whole growing season, but the earlier foliage near the base of the stem perishes and falls, while fresh leaves are still appearing at the summit. In our deciduous trees and shrubs, however, the leaves of the season are all developed within a short period, and they all perish nearly at the same time. They are not destroyed by frost, as is commonly supposed; for they begin to languish, and often assume their autumnal tints (as happens with the Red Maple especially), or even fall, some weeks anterior to the earliest frosts; and when vernal vegetation is destroyed by frost, the leaves blacken and wither, but do not fall off entire, as in autumn. Some leaves fall, perhaps, before they have entirely lost their vitality. Others die and decay on the stem without falling, as in Palms and most Endogens; or else the dead leaves mostly hang on the branches through the winter, as in the Beech and some kinds of Oak, and fall when the new buds expand, the following spring. We must therefore distinguish between the death and the fall of the leaf.

191. The fall of the leaf is owing to the formation of an *articulation*, or joint, between the base of the petiole and the stem on which it rests. The leaf rapidly acquires its full growth, — in a few weeks at farthest, — and, since its base cannot long keep pace with the continually increasing circumference of the stem, especially as the leaf is more and more enfeebled as the season advances, a separation therefore takes place by the formation of a joint, which in our trees is well marked long before frost occurs. When it falls, a well defined scar is left, as in Fig. 72, *b*. But in most Endogenous plants, where the leaves are scarcely, if at all, articulated with the stem, which increases little in diameter subsequently to its early growth, they are not thrown off, but simply wither and decay; their dead bases or petioles being often persistent for a long time.

192. But why do leaves die? Why in all ordinary cases do they only last for a single year, or a single summer? The answer to this question is to be found in the anatomical structure of the leaf, and the nature and amount of the fluid which it receives and exhales. The water which the roots absorb dissolves, as it percolates the soil, a small portion of earthy matter. In limestone districts especially, it takes up a sensible quantity of carbonate and sulphate of lime, and becomes *hard*. It likewise dissolves a smaller proportion of silex, alumen, magnesia, potassa, &c. A part of this mineral matter, we have already stated, is deposited in the woody tissue of the stem (116). But a larger portion is carried into the leaves, where, as the water is exhaled or distilled perfectly pure, all this earthy matter must be left behind to incrust the delicate cells of the parenchyma, much as the vessels in which water is boiled for culinary purposes are in time incrusted with an earthy deposit. This earthy accumulation gradually chokes the tissue of the leaf, obstructs the exhalation, and finally unfits it for the

performance of its offices. Hence the fresh leaves most actively fulfil their functions in spring and early summer; but languish towards autumn, and ere long inevitably perish. Hence, although the roots and branches may be permanent, the necessity that the leaves should be annually renewed.

193. The general correctness of this view may be tested by direct microscopical observation. In Fig. 108, 109, some of the parenchyma thus obstructed by long use is represented; and similar illustrations may be obtained from ordinary leaves. That this deposit consists in great part of earthy matter is shown by carefully burning away the organic matter of an autumnal leaf over a lamp, and examining the ashes by the microscope; which will be found very perfectly to exhibit the form of the cells. The ashes which remain when a leaf or other vegetable substance is burned in the open air represent the earthy materials which it has accumulated. A vernal leaf leaves but the minutest quantity of ashes; an autumnal leaf yields a very large proportion; from ten to thirty times as much as the wood of the same species; although the leaves contain the deposit of a single season only, while the heart-wood is loaded with the accumulations of successive years.*

194. The quantity of water exhaled by the leaves during active vegetation is very great. In one of the well known experiments of Hales, a Sunflower three and a half feet

* The dried leaves of the Elm contain more than eleven *per cent.* of ashes, while the wood contains less than two *per cent.*; those of the Willow, more than eight *per cent.*, while the wood has only 0·45; those of the Beech, 6.69, the wood only 0·36; those of the (European) Oak, 4·05, the wood only 0·21; those of the Pitch-Pine, 3·15, the wood only 0·25 *per cent.* Hence their decaying leaves, in our forests, restore to the soil a large proportion of the inorganic matter which the trees have taken from it.

high, presenting a surface of 5,616 square inches exposed to the air, was found to perspire at the rate of twenty to thirty ounces avoirdupois every twelve hours, or seventeen times more than a man. A vine with twelve square feet of foliage, exhaled at the rate of five or six ounces a day; and a seedling Apple-tree, with eleven square feet of foliage, lost nine ounces a day. The amount varies with the degree of warmth and dryness of the air, and exposure to light; and is also very different in different species, some exhaling more copiously even than the Sunflower. But when we consider the vast perspiring surface presented by a large tree in full leaf, it is evident that the quantity of watery vapor it exhales must be immense. This exhalation is dependent upon the presence of the sun, and is scarcely perceptible during the night. The Sunflower, in the experiment of Hales, lost only three ounces in a warm, dry night, and underwent no diminution during a dewy night.

195. Now this exhalation by the leaves requires a corresponding absorption by the roots. The one is the measure of the other, at least in a healthful condition of the plant. If the leaves exhale more in a given time than the roots can restore by absorption from the soil, the foliage droops; as we see in a hot and dry summer afternoon, when the drain by exhalation is very great, while the parched soil with difficulty yields a further supply of moisture; — as we observe also in a leafy plant newly transplanted, where the injured rootlets are not immediately in a fit condition for absorption. Ordinarily, however, exhalation by the leaves and absorption by the roots are in direct ratio to each other, and the loss sustained by the leaves is immediately restored by the ascent of the sap from the branches, the latter being constantly supplied by the stem; so that, during active vegetation, the sap ascends from the remotest rootlets to the highest leaves, with a rapidity corresponding to the amount

of exhalation. The action of the leaves is, therefore, to a great extent, the cause of the ascent of the sap.* This is beautifully illustrated when a graft has a different time of leafing from that of the stock upon which it is made to grow, the graft wholly regulating the season or temperature

* If we cannot explain the *immediate* cause of the ascent of the sap, it can at least be referred to a more general natural power, which acts according to known laws. If the lower end of an open tube, closed with a thin membrane, such as a piece of moistened bladder, be introduced into a vessel of pure water, and a solution of sugar in water be poured into the tube, the water from the vessel will shortly be found to pass into the tube, so that the column of liquid it contains will increase in height to an extent proportionate to the strength of the solution. At the same time, the water in the vessel will become slightly sweet; showing that a small quantity of syrup has passed through the pores of the membrane into the water without, while a much larger portion of water has entered the tube. The water will continue to enter the tube, and a small portion of syrup to leave it, until the solution is reduced to the same strength as the liquid without. If a solution of gum, salt, or any other substance, be employed instead of sugar, the same result will take place. If the same solution be employed both in the vessel and the tube, no transference or change will be observed. But if either be rendered stronger than the other, a circulation will be established, and the stronger solution will increase in quantity until the two attain the same density. If two different solutions be employed, as, for instance, sugar or gum, within the tube, and potash or soda without, a circulation will in like manner take place, the preponderance being *towards* the denser fluid, and in a degree exactly proportionate to the difference in density. Instead of animal membrane, any vegetable matter with fine pores, such as a thin piece of wood, or any porous mineral substance, may be substituted without affecting the result. Dutrochet, the discoverer of these phenomena, gave the name of *Endosmose* to the movement of

at which the sap is put in motion, and controlling the habits of the original stock.

196. While the sap is thus consumed as fast as it enters the plant, no considerable accumulation can take place: but in autumn, when the leaves perish, the rootlets, buried in the soil beyond the influence of the cold which checks all vegetation above ground, continue for a time slowly to absorb the fluid presented to them. Thus the trunks of many trees are at this season gorged with sap, which will flow from incisions made into the wood. This sap undergoes a gradual change during the winter, and deposits its solid matter in the tubes and cells of the wood. The absorption recommences in the spring long before new leaves

---

these weaker fluid towards the stronger, and that of *Exosmose* to the lesser movement of the stronger towards the weaker solution; —names which it is convenient to retain, although these phenomena are only particular cases of capillary attraction.

Now, as these phenomena appear to be universal, the porous spongelets, or extremities of the root, may be taken to represent the membranous or porous partition between the sap in the root and stem, charged with the gummy, starchy, or sugary matter it has there dissolved, thus increasing its density, and the much less dense fluid which reaches the rootlets from without; in which case the latter ought to enter into the root and stem, as in fact it is found to do. And it should continue to flow into the plant, until the sap in its tubes and cells is reduced to the same density as that of the liquid in the soil to which the rootlets are exposed. This can never happen, however, in a growing plant, where the sap is continually and greatly concentrated by exhalation from the leaves; and consequently, the flow of the sap into the roots, and upward towards the more concentrated portions, ought to continue during the growth of the plant. Whatever other influences may be concerned in the ascending circulation, it cannot be doubted that Endosmosis, combined with exhalation from the leaves, will almost suffice to explain the facts.

are expanded to consume the fluid; the trunk is consequently again gorged with sap, which will flow, or *bleed*, when wounded. But when the leaves resume their functions, or when flowers are developed before the leaves appear, as in many forest-trees, this stock of rich sap is rapidly consumed, and the sap will no longer flow from an incision.

CHAPTER VI.

OF THE FOOD AND NUTRITION OF PLANTS.

197. The Organs of Vegetation or Nutrition (those by which plants grow and form their various products) having been separately considered, both as to the special office of each organ, and as to their combined action, we are prepared to take, from a different point of view, a comprehensive survey of the general phenomena and results of vegetation; to inquire into the elementary composition of plants, the nature of the food by which they are nourished, the sources from which this food is derived, and the transformations it undergoes in their system, chiefly in their digestive apparatus, the leaves. It is in vegetable digestion that the essential nature of vegetation is to be sought, since it is in this process alone that mineral, unorganized matter is converted into the tissue of plants and other forms of organized matter (10). From this point of view, therefore, the reciprocal relations and influences of the mineral, vegetable, and animal kingdoms may be most advantageously contemplated, and the office of plants in the general economy of the world best understood. This portion of general

physiology is intimately connected with chemistry, and some knowledge of that science is requisite for the due comprehension of the subject, especially in relation to its exceedingly important applications to agriculture and horticulture. We are here restricted to the bare statement of the leading facts which are thought to be established, and the more important deductions which may be drawn from them; omitting, for the most part, to adduce the evidence by which these general propositions are supported.

§ 1. The Food and the Elementary Composition of Plants.

198. We are first to consider the food, and the elementary composition of vegetables. These stand in a necessary relation to each other. Since it is not to be supposed that plants possess the power of creating any simple element, whatever they consist of must have been derived from without. Their *composition* indicates their *food*, and *vice versâ*. If we have learned the chemical composition of a vegetable, and also what it gives back to the soil and the air, we know consequently what it must have derived from without, that is, its *food*. Or, if we have ascertained what the plant takes from the soil and air, and what it returns to them, we have learned its chemical composition, namely, the difference between these two. And when we compare the nature and condition of the materials which the plant takes from the soil and the air with what it gives back to them, we may form a correct notion of the influence of vegetation upon the mineral kingdom.

199. By considering the materials of which plants are composed, we may learn what their food must necessarily contain. The constituents of plants are of two kinds.

200. It has been shown (192) that various earthy matters, dissolved by the water which the roots absorb, are

drawn into the plant, and at length deposited in the wood, leaves, &c. These form the ashes which are left on burning a leaf or a piece of wood. Although these mineral matters are often turned to account by the plant, and some of them are necessary in the formation of certain products, (as the silex which gives needful firmness to the stalks of Wheat, and the phosphates which always exist in the grain,) yet none of them are essential to simple vegetation, which may, and often does, proceed as well without them. These materials, the presence of which is in some sort accidental, though in certain cases essential, are distinguished as the *earthy*, or *mineral*, or *inorganic constituents* of plants. This class may be left entirely out of view for the present. But the analysis of any newly formed vegetable tissue, or of any part of the plant, such as a piece of wood, after the incrusting mineral matter has been chemically removed, invariably yields but three or four elements. These, which are indispensable to vegetation, and make up at least from eighty-eight to ninety-nine *per cent.* of every vegetable substance, are termed the *universal*, *organic constituents* of plants. They are carbon, hydrogen, oxygen, and nitrogen. The proper vegetable structure, that is the substance of the cells and vessels, uniformly consists of only three of these elements, namely, carbon, hydrogen, and oxygen. These are absolutely essential and universal; while the fourth, nitrogen, is only requisite in the formation of certain very important products.

201. These four elements must be furnished by the food upon which the vegetable lives; — they must be drawn from the soil and the air; in some cases doubtless from the latter source, as in Epiphytes, or Air-plants (63), but generally and principally by absorption through the roots. The plant's nourishment is wholly absorbed either in the gaseous or the liquid form; for the leaves can imbibe air

12 *

or vapor only (138), and the hygrometic tissue of the rootlets is especially adapted to absorb liquids.

202. In whatever mode imbibed, evidently the main vehicle of the plant's nourishment is *water*, which as a liquid bathes its roots, and in the state of vapor continually surrounds its leaves. We have seen how copiously water is taken up by the growing plant, and have formed some general idea of its amount by the quantity that is exhaled unconsumed by the leaves. But pure water, although indispensable, is insufficient for the nourishment of plants. It consists of oxygen and hydrogen; and therefore may furnish, and doubtless does principally furnish, these two essential elements of the vegetable structure. But it cannot supply what it does not itself contain, namely, the carbon and nitrogen which the plant also requires.

203. Yet the question arises, whether the water which the plant actually imbibes contains in fact a quantity of these remaining elements. Though pure water cannot, may not *rain-water* supply the needful carbon and nitrogen? It is evident that if the immense quantity of water which filtrates through the leafy plant (194) contain even a very minute quantity of these ingredients, in such a form that they may be detained when the superfluous water is exhaled, this might furnish the whole organic food of the vegetable; since the plant may condense and accumulate the carbon and nitrogen, just as the extremely minute quantity of earthy matter which the water contains is at length largely accumulated in the leaves and wood.

204. As respects the nitrogen, nearly seventy-nine *per cent.* of the atmosphere consists of this gas in an uncombined or free state, that is, merely mingled with oxygen. And, being soluble to some extent in water, every raindrop that falls through the air absorbs and brings to the ground a minute quantity of nitrogen, which is therefore

necessarily introduced into the plant with the water which the roots imbibe. This accounts for the free nitrogen which is always found in growing plants.

205. The plant also receives probably a larger portion of its nitrogen in the form of ammonia (or hartshorn), a compound of hydrogen and nitrogen, which is always produced when any animal and almost any vegetable substance decays, and which, being very volatile, must continually rise into the air from these and other sources. The extreme solubility of ammonia and all its compounds prevents its accumulation in the atmosphere, from which it is greedily absorbed by aqueous vapor, and brought down to the ground by rain. That the roots actually absorb it may be inferred from the familiar facts, that plants grow most luxuriantly when the soil is supplied with substances which yield much ammonia, such as most manures; and that ammonia may be detected in the juices of almost all plants. Rain-water, therefore, contains the third element of vegetation, namely, nitrogen, both in a separate form, and in that of ammonia.

206. The source of the remaining constituent, carbon, is still to be sought. Of this element plants must require a copious supply, since it forms the largest portion of their bulk. If the carbon of a leaf or of a piece of wood be obtained separate from the other organic elements, — which may be done by charring, that is by heating it out of contact with the air, so as to drive off the oxygen, hydrogen, and carbon, — although a small part of the carbon is necessarily lost in the operation, yet what remains perfectly preserves the shape and bulk of the original body, even to that of its most delicate cells and vessels. With the exception of the ashes, this consists of carbon, or charcoal, amounting to from forty to sixty *per cent.* by weight, of the original material. Carbon is itself a solid, absolutely in-

soluble in water, and therefore incapable of assumption by the plant. The chief, if not the only fluid compound of carbon which is naturally presented to the plant, is that of carbonic acid gas, which consists of carbon united with oxygen. This gas makes up on the average one two-thousandth of the bulk of the atmosphere; from which it may be directly absorbed by the leaves. But, being freely soluble in water up to a certain point, it must also be carried down by the rain and imbibed by the roots. The carbonic acid of the atmosphere is therefore the great source of carbon for vegetation.

207. It appears, then, that the atmosphere—considering water in the state of vapor to form a component part of it—contains all the essential materials for the growth of vegetables, and in the form best adapted to their use, namely, in the fluid state. It furnishes water, which is not only food itself, inasmuch as it supplies oxygen and hydrogen, but is likewise the vehicle of the others, conveying to the roots what it has gathered from the air, namely, the requisite supply of nitrogen, either separately or in the form of ammonia, and of carbon in the form of carbonic acid.

208. These essential elements, the whole *proper food* of plants, *may be* absorbed by the leaves directly from the air, in the state of gas or vapor. Doubtless most plants actually take in a portion of their food in this way, at least when other supply is arrested. A vigorous branch of the common Live-for-ever (Sedum Telephium), or of many such plants, it is well known, will live and grow for a whole season when pinned to a dry, bare wall; and the Epiphytes, or Air-plants (63), as they are aptly called, must derive their whole sustenance immediately from the air; for they have no connection with the ground.

209. But the peculiar office of leaves is something different from that of absorbing nourishment. As a compre-

hensive statement, leaving extraordinary cases out of view, it may be said that plants, although they derive their food from the air, receive it through their roots. The *aqueous vapor*, condensed into rain or dew, and bringing with it to the ground a portion of *carbonic acid*, and of *nitrogen* or *ammonia*, &c., supplies the appropriate food of the plant to the rootlets. Imbibed by these, it is conveyed through the stem and into the leaves, where the now superfluous water is restored to the atmosphere by exhalation,* while the residue is converted into the proper nourishment and substance of the vegetable.

210. The atmosphere is therefore the great storehouse from which vegetables derive their nourishment; and it might be clearly shown that all the constituents of plants, excepting the small earthy portion that many can do without, have at some period formed a part of the atmosphere. The vegetable kingdom represents an amount of matter

---

* The water exhaled may be again absorbed by the roots, laden with a new supply of the other elements from the air, again exhaled, and so on; as is beautifully illustrated by the cultivation of plants in closed *Ward cases*, where plants are seen to flourish for a long time with a very limited supply of water, every particle of which (except the small portion actually *consumed* by the plants) must pass repeatedly through this circulation. This vegetable microcosm accurately exhibits the actual relations of water, &c., to vegetation on a large scale in nature; where the water is alternately and repeatedly raised by evaporation and re-condensed to such extent that what actually falls in rain is estimated to be re-evaporated and rained down (on an average throughout the world) ten or fifteen times in the course of a year. In this way the atmosphere is repeatedly washed by the rain; and those vapors *washed out* which else by their accumulation would prove injurious to men and animals, and conveyed to the roots of plants, which they are especially adapted to nourish.

which the force of organization has withdrawn from the air, and confined for a time to the surface.

211. Does it therefore follow that the soil merely serves as a foothold to plants, and that all vegetables obtain their whole nourishment directly from the atmosphere? This must have been the case with the first plants that grew, when no vegetable or animal matter existed in the soil; and no less so with the first vegetation that covers small volcanic islands raised in our own times from the sea, or the surface of lava thrown from ordinary volcanoes. No vegetable matter is brought to these perfectly sterile mineral soils, except the minute portion contained in the seeds wafted thither by winds or waves. And yet in time a vast quantity is produced, which is represented not only by the existing vegetation but by the mould that the decay of previous generations has imparted to the soil. We arrive at the same result by the simple experiment of causing a seed of known weight to germinate on powdered flints, watered by rain-water alone. When the young plant has attained the fullest development of which it is capable under these circumstances, it will be found to weigh (after due allowance for the silex it may have taken up) perhaps fifty or one hundred times as much as the original seed. There can be no question as to the source of this vegetable matter in all these cases. *The requisite materials exist in the air. Plants possess the peculiar faculty of drawing them from the air. The air must have furnished the whole.* This conclusion is amply confirmed by a great variety of familiar facts; such as the accumulation of vegetable matter in peat bogs, and of mould in neglected fields, in old forests, and generally wherever vegetation is undisturbed. Since this rich mould, instead of diminishing, regularly increases with the age of the forest and the luxuriance of its vegetation, the trees must have drawn from the air not only the

vast amount of carbon, &c., that is stored up in their trunks, but an additional quantity which is imparted to the soil in the annual fall of leaves, &c.

212. Still it by no means follows, that each plant draws all its nourishment directly from the air. This unquestionably happens in some of the special cases just mentioned; with Air-plants, and with those that first vegetate on volcanic earth, bare rocks, naked walls, or pure sand. But it is particularly to be remarked, that only certain tribes of plants will continue to live under such circumstances, and that none of the vegetables most useful as food for man or the higher animals will thus thrive and come to maturity. In nature, the races of plants that will grow at the entire expense of the air, such as Lichens, Mosses, Ferns, and certain succulent tribes of Flowering Plants, gradually form a soil of vegetable mould during their life, which they increase in their decay; and the successive generations live more vigorously upon the inheritance, being supported partly upon what they draw from the air, and partly upon the ancestral accumulation of vegetable mould. Thus, each generation may enrich the soil, even of those plants that draw largely upon vegetable matter thus accumulated; for it annually restores a portion by its dead leaves, &c., and when it dies it bequeaths to the soil not only all that it took from it, but all that it drew from the air. It is in this way that the lower tribes and so-called useless plants create a soil, which will in time support the higher plants of immediate importance to man and the higher animals, but which could never grow and perfect their fruit, if left, like their humble but indispensable predecessors, to derive an unaided subsistence directly from the inorganic world. While it is strictly true, therefore, that all the organic elements have been originally derived from the air, it is not true that what is contained in almost any given plant, or in

any one crop, is immediately drawn from this source. A part of it is thus supplied, perhaps in almost every case, but in proportion varying greatly in different species and under different circumstances. Undisturbed vegetation consequently tends always to enrich the soil. But in agriculture the crop is ordinarily removed from the land, and with it not only what it has taken from the earth, but also what it has drawn from the air; and the soil is accordingly impoverished. Hence the farmer finds it necessary to follow the example of nature, and to restore to the land, in the form of manure, an amount substantially equivalent to what he takes away.

213. The mode in which vegetable mould is turned to account by growing plants has not yet been sufficiently investigated. According to one, perhaps the prevailing view, the decaying vegetable matter is not employed until it has been resolved into its original inorganic elements, namely, into water, carbonic acid, ammonia, &c.; which, slowly absorbed by the water that percolates the soil, are imbibed by the roots. Others suppose, and the economy of parasitic plants confirms this view, that a portion of the food which plants derive from decaying vegetable matter may consist of soluble, still organic compounds.

214. The alkaline and earthy matters, which form the inorganic constituents of plants (200), are furnished by the soil; from which each species takes up, or rather retains, various materials in very different proportions, according to its nature and constitution. The ashes of different species, which have grown in the same soil, contain either different substances, or the same substances in very unlike proportions. Thus, if a Bean, a Pea, and a grain of Wheat, be grown side by side, the stem of the latter will be found to contain a considerable quantity of silex (nearly three-tenths of its ashes consisting of that substance); that of the Pea

a very small proportion (twenty-two hundredths of one *per cent.*); and that of the Bean only one fourth of the quantity found in the Pea, or one thirteenth of that contained in Wheat-straw. These three plants accordingly abstract alkali, as well as silex, from the soil in very different proportions. If they be allowed to produce fruit and ripen their seeds, the latter will be found to contain, in the Wheat, a considerable quantity of phosphate of magnesia, &c., but in the Pea and Bean scarcely any. It is therefore apparent, that while a crop of Wheat robs the soil of certain alkaline and other inorganic matters necessary to its proper growth, Peas and Beans leave these substances almost untouched. This explains the utility of the latter as fallow crops, since they add to the land a portion of the carbonaceous matter they have derived chiefly from the air, while they scarcely diminish its alkalies and phosphates, which are required for the succeeding Wheat-crop. These alkaline and other constituents of the soil, it may here be remarked, are primarily derived from the slow disintegration and decomposition of the rocks and earths that compose it,* or are added in the form of manure.

---

* According to Liebig, the quantity of potash contained in a layer of soil formed by the disintegration of 40,000 square feet of the following rocks, &c., to the depth of twenty inches, is as follows. This quantity of Feldspar (a large component of granite, &c.) contains . . . 1,152,000 lbs.

Clinkstone, . .	from	200,000	to	400,000 "
Basalt, . . .	"	47,500	"	75,000 "
Clay-slate, . .	"	100,000	"	200,000 "
Loam . . .	"	87,000	"	300,000 "

The silex yielded to the soil by the gradual decomposition of granite and other rocks, is in the form of a silicate of potash or other alkali, which, though insoluble in pure water, is slowly acted upon and dissolved by the united action of water and carbonic

215. The amount or proportion, as well as the kind of earthy matter, is nearly constant in the same species when grown in widely different soils; provided that the substances which the plant requires are present in the soil at all. When this is not the case, its growth is checked, or it fails to ripen its fruit or form its peculiar products, and eventually perishes. One alkaline base may, however, sometimes takes the place of another: a plant which requires potash or magnesia supplies itself with soda or lime, when the former is not accessible.

216. It being, therefore, indispensable that a plant should find in the soil the mineral matters necessary to its growth or perfect development, we are enabled to understand why various species will only flourish in particular soils or situations; why plants which take up common salt, &c., are restricted to the sea-shore and to the vicinity of salt-springs; and why Pines and Firs, the ashes of which contain very little alkali, will thrive in the thinnest and most sterile soil, while the Beech, Maple, Elm, &c., abounding with potash, are only found in strong and fertile land.

217. It has been the prevalent opinion, that the roots of plants possess no power of selecting their food, but take up indiscriminately whatever is presented to them in a liquid form; a view which is supported by the well known fact, that plants may be made to absorb various substances incapable of assimilation, and in no way contributing to their growth, or even poisons which destroy them. It has hence been inferred, that all matters in the soil soluble to any extent in the water impregnated with carbonic acid, &c., which forms the ordinary food of plants, are equally introduced

---

acid, or more largely by water impregnated with carbonate of potash, which is abundantly liberated during the natural decomposition of these rocks.

into their circulation; and that those materials required by each particular species are retained and gradually accumulated, while the others, passing into the downward circulation, are returned to the soil. But the selecting power, here assumed for the tissue in which these substances are accumulated or assimilated, may perhaps be shared by the rootlets. It is well known that some roots refuse to take up certain colored infusions which are readily imbibed by others; that many plants cannot be made to absorb a solution of strontia, while they freely take up the salts of lime; and that some (Polygonum Persicaria, for example), which refuse to admit acetate of lime, readily absorb common salt. It appears, moreover, that the various mineral matters contained in the ashes of a plant are by no means proportional, either to their respective quantities in the soil, or to their degree of solubility.

218. It is therefore not improbable that roots do possess a certain power of discrimination, by which they generally select from the soil the matters best fitted to promote their growth; and that when some of these are not to be met with, they admit analogous substances in their stead, or at least in increased proportions. Thus, where a plant which usually contains a large quantity of phosphate of magnesia, and very little phosphate of lime, is unable to procure a due supply of the former, the latter is correspondingly increased. But the roots possess at most a very limited power in this respect. The principal selection is made in the organs which appropriate mineral elements (as the fruit, &c.), which accumulate certain materials, and exert no influence upon others. So the wood of the Mistletoe (64) when parasitic upon the Apple-tree is found to contain twice as much potash, and five times as much phosphoric acid, as the wood of the foster tree.

219. In addition to their principal office (that of absorb-

ing food), roots have been supposed to be *excretory* organs, by giving out to the soil the useless or hurtful matters that may have been received into the circulation of the plant, as well as a portion of its peculiar products. That such excretions are thrown out is highly probable; but there is no proof of their accumulation in the soil so as to be injurious to the plant itself, or that they constitute appropriate sustenance for a different species; and the theory which thus attempts to explain the benefits of a rotation of crops appears to be destitute of sufficient foundation. Land is rendered sterile by the abstraction of the organic, and the soluble alkaline matters, which a fertile soil contains, and which are gradually taken away by the crops. If the supply be artificially kept up, full crops of the same kind of grain may be constantly obtained from a given soil for an indefinite period. But a soil which will no longer yield a full crop of some particular kind of grain, on account of the exhaustion of the substances it requires, may yet be perfectly adapted to a different species, which requires little or none of this peculiar food: meanwhile the supply of the needful soluble inorganic matter is slowly restored, by the disintegration and decomposition of the mineral constituents of the soil.*

---

* The principal part of the earthy matter which forms the ashes left after the combustion of wood, leaves, &c., especially of that which exists in a crystalline state, probably consists of oxalates, which are converted into carbonates in burning. Professor Bailey has shown that the crystals or raphides (37) they so copiously contain are chiefly oxalate of lime; though some, no doubt, are phosphates. The immediate source of this oxalic acid, and the part it plays in the vegetable economy, becomes a very interesting inquiry. — See Professor Bailey's valuable paper *On the Crystals in the Tissues of Plants*, in the *American Journal of Science*, for January, 1845.

§ 2. Vegetable Digestion and its Consequences.

220. We have reached the conclusion, that the universal food of plants is rain-water, which has absorbed some carbonic acid gas and nitrogen (partly in the form of ammonia or of other compounds) from the air, or dissolved them from the remains of former vegetation already existing in the soil, whence it has also taken up a variable (but in some respects essential) quantity of earthy matter.

221. This fluid, imbibed by the roots, and carried upwards through the stem, receives the name of *sap*, or *crude sap*. During its ascent, its properties are often more or less altered, chiefly by dissolving the soluble organized matter it meets with; thus becoming sweet in the Maple, &c., and acquiring different sensible properties in different species. This dissolved portion consists of elaborated food, and may therefore be immediately consumed in vegetable growth. But the crude sap itself is merely raw material, unorganized, mineral matter, as yet incapable of forming a part of the living structure. Its assimilation or conversion into organized matter constitutes what is termed *vegetable digestion*. For this purpose the crude sap is carried into the leaves, or other green parts of the plant, which constitute the apparatus of vegetable digestion.

222. The motive power of this curious apparatus is *solar light*. Under the influence of light the fabric is constructed, and the *chromule*, or *chlorophylle* (36), the green matter of plants, upon which the light exerts its wonderful action, is first developed. When plants are made to grow in insufficient light, as when potatoes throw out shoots in our cellars, this green matter is not formed. When light is withdrawn, it is soon decomposed; as we see when Celery is blanched by heaping the soil around its stems. So, also,

the naturally uncolored leaves of plants parasitic upon the roots or stems of other species, as the Monotropa, or Indian Pipe (Fig. 682), take no part in vegetable digestion. But all green parts of plants, such as the cellular outer bark of most herbs, act upon the sap in the same manner as leaves, even supplying their place in plants which produce few or no leaves, as in the Cactus, &c. Under the influence of light, an essential preliminary step in vegetable digestion is accomplished, namely, the concentration of the crude sap by the evaporation or exhalation of the now superfluous water, the mechanism and various consequences of which have already been considered (141, 192 – 196).

223. We have only to consider the further agency of light in the essential process of vegetable digestion itself, namely, its action in the leaf upon the concentrated sap. Here it accomplishes two perfectly unparalleled results, upon which all organized existence absolutely depends. These are, 1st. *The chemical decomposition of one or more of the substances in the sap which contain oxygen gas, and the liberation of this oxygen at the ordinary temperature of the air.* The chemist can in certain cases liberate oxygen gas from its compounds, but only with aid of powerful reagents, or of a heat equal to that of red-hot iron. 2d. *The actual transformation of this mineral food, this inorganic into organic matter,— the organized substance of living plants, and consequently of animals.* These two operations, although separately stated to convey a clearer idea of the results, are in fact but different aspects of one great process. We contemplate the first, when we consider what the plant gives back to the air;—the second, when we inquire what it retains as the materials of its own growth. The concentrated sap is decomposed; the portion which is not required in the growth of the plant is returned to the air; and the remaining elements are at the same time rearranged, so as to form peculiar, *organic* products.

224. The principal material given back to the air, in this process, is oxygen gas, that element of our atmosphere which alone renders it fit for the breathing and life of animals. That the foliage of plants in sunshine is continually yielding oxygen gas to the surrounding air has been familiarly known since the days of Ingenhouss and Priestley; and may at any moment be verified by simple experiments. The readiest way is, to expose a few freshly gathered leaves to the sunshine in a glass vessel filled with water, and to collect the air-bubbles which presently arise while the light falls upon them, but which immediately cease to appear when placed in shadow. This air, when examined, proves to be pure oxygen gas. In nature, diffused daylight produces this result; but in our rude experiments, direct sunshine is generally necessary. What is the source of this oxygen gas, which is given up to the air just in proportion to the vigor of vegetation, or, in other words, to the consumption of the sap?

225. To take for illustration the case which is at once the simplest and the most general, we will suppose the plant is converting its food directly into the materials of its own growth, that is, into the very matter of which new cells and fibres consist. This matter, sometimes called *lignin* or *cellulose*, when in a pure state, and free from incrusting materials, has a perfectly uniform composition in all plants. It is composed of carbon, hydrogen, and oxygen, of which the latter two exist in the same proportions as in water. It may therefore be said to consist of carbon and the elements of water. These materials are necessarily furnished by the plant's food. But the universal food of the plant, that which is only and absolutely essential to bare vegetation (200–209), is carbonic acid and water. If this be decomposed in vegetation, and the carbonic acid give up its oxygen, there remains carbon and water, or rather the

elements of water,— the very composition of lignin or vegetable tissue. Doubtless, then, the oxygen which is rendered to the air in vegetation comes from the carbonic acid which, as we have seen (206), the plant took from the air.

226. This view may be confirmed by direct experiment. We have seen that many plants *must*, and all *may*, imbibe the whole or a part of the carbonic acid they consume directly from the air into their leaves (208, 206). It is accordingly found that when a current of carbonic acid is made slowly to traverse a glass globe containing a leafy plant exposed to the full sunshine, the carbonic acid disappears, and an equal bulk of oxygen gas supplies its place. Now, since carbonic acid gas contains just its own bulk of oxygen, it is evident that what has thus been decomposed in the leaves has returned all its oxygen to the air. Plants take carbonic acid from the atmosphere (directly or indirectly); they retain its carbon; they give back pure oxygen.

227. We may next suppose that the plant's food, instead of being immediately converted into new cells, new branches, &c., is accumulated in an elaborated state for future use. In that case, it is first converted into *gum*, or *mucilage*, or *dextrine*, and usually stored up in the form of *starch* (36), either in the root (58), or in subterranean portions of the stem (87), or in the wood, &c.; and when this store of nourishing matter is eventually consumed in growth, it is generally reconverted into *dextrine* (which is merely a form of starch, soluble in cold water), and thence into vegetable tissue. Now it is worthy of especial remark, that these convertible substances, gum, dextrine, starch,* &c., are perfectly

* This whole class of organic products consists, as represented in a chemical form, of 12 atoms of carbon = 72, 10 atoms of hydrogen = 10, and 10 of oxygen = 80, = 162.

identical in chemical composition, both with each other and with lignin or vegetable tissue. The composition of the whole class is represented by carbon, and the elements of water; and in their formation, the carbonic acid of the sap has yielded all its oxygen to the air. Sometimes the digested food is accumulated in the more soluble form of *sugar*, as in the stalk of the Sugar-cane and Maize just before flowering, in the root of the Beet, &c. But sugar has the same chemical composition as starch, vegetable tissue, &c., with the addition of another atom of water in the case of Cane-sugar, and of three atoms in that of Grape-sugar. In the formation of all these products, therefore, the same quantity of carbonic acid is consumed, and all its oxygen restored to the air.* It is more and more evident, there-

* Since this whole class of neutral ternary substances are identical or nearly so in chemical composition; and since, with the same amount of carbon, derived from the decomposition of carbonic acid, the plant can form these various products, notwithstanding the great difference in their external characters, it will no longer appear so surprising that they should all be so readily convertible into each other in the living plant, and even in the hands of the chemist. But the chemistry of organic nature exceeds the resources of science, and constantly produces transformations which the chemist in his laboratory is unable to effect. The latter can change starch into gum, and gum into sugar; but he cannot reverse the process, and convert sugar into gum, and gum into starch. In the plant, however, all these various transformations are continually taking place. Thus, the starch deposited in the seed of the Sugar-cane, as in all other Grasses, is changed into sugar in germination; and the sugar which fills the tissue of the stem at the time of flowering is rapidly carried into the flowers, where a portion is transformed into starch and again deposited in the newly-formed seeds. And although the chemist is unable to transform starch, sugar, &c., into lignin, yet he readily effects the opposite change, by reconverting woody fibre, &c.,

fore, that, by just so much as plants grow, they take carbonic acid from the air, they retain its carbon, and return its oxygen.

228. One class of vegetable products, to which the oils and resinous substances belong, contain either no oxygen at all, or a smaller quantity than is requisite to convert their hydrogen into water. During their formation, therefore, not only all the oxygen of the carbonic acid has been given out, but also a portion belonging to the water. Another class, the vegetable acids, contain more oxygen than is necessary for the conversion of their hydrogen into water, but less than the amount which exists in carbonic acid and water. These acids are sometimes formed in the leaves, as in the Sorrel, the Grape-vine, &c., but usually in the fruit. If they are produced directly from the sap, as is probably the case in acid leaves, only a part of the oxygen in the carbonic acid which contributes to their formation would be exhaled. But if they are formed from gum, sugar, or any other of the general products of the proper juice, the absorption of a portion of oxygen from the air would be required for the conversion; and this absorption takes place (at least in some cases) when fruits acquire their acidity. Neither of these two classes of vegetable products appears to perform any essential office in the general phenomena of vegetable growth.

229. There is still another important class of vegetable products, namely, the quaternary organic compounds, of which nitrogen is a constituent. One of the most important of these is *gluten*, a tenacious substance which exists in most seeds, especially of the Grasses cultivated for grain,

---

first into starch, and then into sugar. The plant does the same thing in the ripening of many fruits, during which woody tissue is transformed into sugar.

as well as in other parts of plants. It constitutes from eight to thirty-five *per cent.* of wheat-flour,* and gives to the dough its peculiar tenacity, and capability of being *raised.* Another, called *legumin*, which abounds in peas, beans, and other leguminous seeds, has recently been ascertained to be identical in composition with the *casein* of milk. *Vegetable albumen* and even *fibrin* are also more or less largely produced by most plants. In the production of this class of products, the ammonia, or other nitrogenized food of the plant plays an essential part; and oxygen is restored to the air, as in the general case of vegetation, from the decomposition of carbonic acid.

230. As concerns the atmosphere, the principal result of vegetation, therefore, consists in the withdrawal of carbonic acid and the restoration of its oxygen. This is a constant effect of vegetation, and the measure of its amount. It is true, indeed, that leaves decompose carbonic acid only in the full light of day; and that in the night they sometimes impart a quantity of carbonic acid to the air, or even take from it a little oxygen. But this does not affect the general result, nor require any qualification of our statement. The work ceases, merely, when light is withdrawn. The plant is then merely in a passive state. Yet, whenever exhalation from the leaves slowly continues in darkness, the carbonic acid which the water holds necessarily flies off with it, during the interruption to vegetation, into the atmosphere from which the plant took it. So much of the crude sap, or raw material, merely runs to waste. Furthermore, it must be remembered, that the decomposition of carbonic acid in vegetation is in direct opposition to ordinary chemical affin-

* The quantity of gluten in wheat varies greatly with the mode of cultivation, and is largest when the soil is best supplied with manures that abound in nitrogen.

ity; or in other words, that all organized matter is in a state of unstable equilibrium. Consequently, when light is withdrawn, ordinary chemical forces may perhaps to some extent resume their sway, the oxygen of the air combine with some of the newly deposited carbon to reproduce a little carbonic acid, and thus demolish a portion of the rising vegetable structure which the setting sun left in an unfinished and unstable state. This is what actually takes place in a dead plant at all times, and whenever an herb is kept in prolonged darkness; chemical forces exerting their power uncontrolled demolish the whole vegetable fabric, beginning with the chlorophylle (as we observe in blanching Celery), and at length resolve it into the carbonic acid and water from which it was formed. But this must all be placed to the account of *decomposing*, not of *growing* vegetation; and even if it were an universal phenomenon, which is by no means the case,* would not affect the general statement, that, *by so much as plants grow*, they decompose carbonic acid and give its oxygen to the air; or, in other words, purify the air.

231. Every six pounds of carbon in existing plants has

---

* In repeating the old experiments upon this subject with due precautions, and with improved means of research, it is found that many ordinary plants, when in full health and vigorous vegetation, *impart no carbonic acid to the air during the night.* — See Pepys in *Philosophical Transactions*, for 1843. — They deteriorate the air only in their decay, and under peculiar circumstances, hereafter to be mentioned. This evolution of carbonic acid by plants, therefore, which has so long been taken for granted, and misinterpreted, has no existence as a general phenomenon. And it is by an entirely false analogy that this *loss* which plants sustain in the night has been dignified with the name of *vegetable respiration*, and vegetables said to vitiate the atmosphere, just like animals, by their respiration, while they purify it by their digestion.

withdrawn twenty-four pounds of carbonic acid gas from the atmosphere, and replaced it with sixteen pounds of oxygen gas, occupying the same bulk. To form some general conception of the extent of the influence of vegetation upon the air we breathe, we should compute the quantity of carbon, or charcoal, that is contained in the forests and herbage of the world, and add to the estimate all that exists in the soil as vegetable mould, peat, and in other forms; all that is locked up in the vast deposits of coal (the product of the vegetation of by-gone ages); and finally all that pertains to the whole existent animal kingdom; — and we shall have the aggregate amount of a single, though the largest, element which vegetation has withdrawn from the atmosphere. By multiplying this vast amount of carbon by sixteen, and dividing it by six, we may obtain an expression of the number of pounds of oxygen gas that have in this process been supplied to the atmosphere.

232. Rightly to understand the object and consequences of this immense operation, which has been going on ever since vegetation began, it should be noted, that, so far as we know, vegetation is the only operation in nature which gives to the air free oxygen gas, that indispensable requisite to animal life. There is no other provision for maintaining the supply. The prevailing chemical tendencies, on the contrary, take oxygen from the air. Few of the materials of the earth's crust are saturated with it; some of them still absorb a portion from the air in the changes they undergo; and none of them give it back in the free state in which they took it, — in a state to support animal life, — by any known natural process, at least upon any considerable scale. Animals all consume oxygen at every moment of their life, giving to the air carbonic acid in its room; and when dead, their decaying bodies consume still more. De-

composing vegetable matter produces the same result. Its carbon, taking oxygen from the air, is likewise restored in the form of carbonic acid. Combustion, as in burning our fuel, amounts to precisely the same thing; it is merely rapid decay. The carbon which the trees of the forest have gathered from the air in the course of centuries, their prostrate decaying trunks may almost as slowly restore to the air in the original form of carbonic acid. But if set on fire, the same result may be accomplished in a day.

233. All these causes conspire to rob the air of its life-sustaining oxygen. The original supply is indeed so vast, that, were there no natural compensation, centuries upon centuries would elapse before the amount of oxygen could be so much reduced, or that or carbonic acid increased, as to affect the existence of the present races of animals. But such a period would eventually arrive, were there no natural provision for the decomposition of the carbonic acid constantly poured into the air from these various sources, and for the restoration of its oxygen. We have seen that vegetation accomplishes this very result. The needful compensation is therefore found in the vegetable kingdom. While animals consume the oxygen of the air, and give back carbonic acid which is injurious to their life, this carbonic acid is the principal element of the food of vegetables, is consumed and decomposed by them, and its oxygen restored for the use of animals. Hence the perfect adaptation of the two great kingdoms of living beings to each other; — each removing from the atmosphere what would be noxious to the other; — each yielding to the atmosphere what is essential to the continued existence of the other.*

* It is plain, however, that, while the animal kingdom is entirely dependent on the vegetable, as no process of theirs restores the oxygen they consume to the atmosphere, yet the latter is, in

234. The relations of simple vegetation, under this aspect, to the mineral kingdom on the one hand and the animal kingdom on the other, may be illustrated after the manner set forth in the first part of the diagram placed at the close of this chapter.

235. But, besides this remotely though truly essential office in purifying the air, the vegetable kingdom renders to the animal another service so immediate, that its failure for a single year would nearly depopulate the earth; namely, in providing the necessary food for the whole animal kingdom. It is under this view, that the grand office of vegetation in the general economy of the world is to be contemplated. Plants are the sole producers of nourishment. They alone transform mineral, chiefly atmospheric materials, they condense air, into organized matter. While they thus *produce* upon a vast scale, they *consume* or destroy comparatively little; and this never in proper vegetation, but in some special processes hereafter to be considered (243). Often when they appear to consume their own products they only transform and transfer them (57, 58), as when the starch of the Potato is converted into new shoots and foliage.

236. Animals *consume* what vegetables produce. They themselves produce nothing directly from the mineral world. The herbivorous animals take from vegetables the organ-

---

a good degree at least, independent of the former, and might have existed alone. The decaying races of plants, giving back their carbon to the air and to the soil (232) would furnish food for their successors. And since all the carbonic acid which animals render to the air in respiration they have derived from their vegetable food, the latter would in time have found its way back to the air, for the use of new generations of plants, without the intervention of animals. At most they merely expedite its return.

ized matter which they have produced; — a part of it they consume, and in respiration restore the materials to the atmosphere from which plants derived them, in the very form in which they were taken, namely, as carbonic acid and water.* The portion they accumulate in their tissues constitutes the food of carnivorous animals; who consume and return to the air the greater part during life, and the remainder in decay after death. The atmosphere, therefore, out of which plants create nourishment, and to which animals as they consume return it, forms the necessary link between the animal and vegetable kingdoms, and thus completes the great cycle of organic existence. Organized matter passes through various stages in vegetables, is raised to higher conditions in the herbivorous animals, — undergoes its final transformations in the carnivorous animals. Portions are consumed at every stage, and, leaving the ascending current, fall back to the mineral kingdom, to which the whole, having accomplished its revolution, finally returns.

237. Plants not only furnish all the materials of the animal fabric, but furnish each principal constituent ready-formed, so that the animal has only to appropriate it. For example, the *fat* of an herbivorous animal (although it doubtless may be produced in the animal economy by a transformation of the starch, sugar, &c.) is principally drawn from the oil and the waxy matters which his vegetable food contains, and which pass, without essential chemical change, into the state of fat in animals, to be by them finally resolved in respiration into carbonic acid and water. The *fibrin*, which forms the muscles and much of the blood, the *casein*, which forms the curd of cheese, the *albumen*, and the *gelatine*, of which the sinews and the organic part

---

* See the diagram at the close of the chapter.

of the bones consist, are all essentially the same in composition as the *gluten* of flour, *vegetable albumen*, the *legumin* of beans, &c., which exist ready-formed in the seeds and herbage of the grass, &c., upon which the animal feeds.* The earthy portion of the bones, the iron in the blood, and all the saline ingredients of the animal body (with the exception of common salt, which is sometimes taken directly from the mineral kingdom), are equally drawn ready-formed from the earthy constituents (214) of the plants upon which the animal feeds. The animal merely appropriates and accumulates these already organizable materials, changing them it may be, little by little, as he destroys them, but rendering them all back finally to the earth and air from which, and in the condition in which, the vegetable took them.

238. The relations of vegetation to the mineral and animal kingdoms, as especially concerns the elaboration of the proper constituents of the animal body, is shown in the second part of the subjoined diagram.

---

* These nitrogenized or neutral quartenary substances are mutually convertible like starch, sugar, lignin, &c., and form a class of products that bears the same relations to the animal, that these do to the vegetable economy.

Diagram illustrating the mutual Relations of the three Kingdoms of Nature.

I. *Simple Vegetation.*

Mineral Kingdom.	Vegetable Kingdom.		Animal Kingdom.	Mineral Kingdom.
WATER { Oxygen, Hydrogen	Oxygen, Hyd ogen	= { Vegetable tissue, Starch, Sugar, &c.	Consumed by animals and in respiration returned to the air, as	Oxygen, Hydrogen } WATER.
CARBONIC ACID { Carbon, Oxygen	Carbon			Carbon, Oxygen } CARBONIC ACID.

II. *Nitrogenized Elements.*

Mineral Kingdom.	Vegetable Kingdom.		Animal Kingdom.	Mineral Kingdom.
AMMONIA { Hydrogen, Nitrogen	Hydrogen, Nitrogen	= Gluten, Legumin, &c.	forming { Fibrin (Muscle), Gelatin (Sinews), Casein (Curd), &c. — returned as	Hydrogen, Nitrogen } AMMONIA.
WATER { Hydrogen, Oxygen	Hydrogen, Oxygen			Hydrogen, Oxygen } WATER.
CARBONIC ACID { Carbon, Oxygen	Carbon			Carbon, Oxygen } CARBONIC ACID.

CHAPTER VII.

OF FLOWERING AND ITS RESULTS.

239. We have hitherto considered plants only in relation to their *Organs of Vegetation* or *Nutrition;* those which essentially constitute the vegetable being, by which it grows, deriving its support from the surrounding air and soil, and converting these inorganic materials into its own organized substance. As every additional supply of nourishment furnishes materials for the development of new branches, roots, and leaves, thus multiplying both those organs which receive food, and those which digest it, it would seem that, apart from accidents, the increase and extension of plants would be limited only by the failure of an adequate supply of nourishment. After a certain period, however, varying in different species, but nearly constant in each, a change ensues, which controls this otherwise indefinite extent of the branches, and is attended with very important results. A portion of the buds, instead of elongating into branches, are developed in the form of FLOWERS (49); and the nourishment, which would otherwise contribute to the general increase of the plant, is partially or wholly expended in their production, and in the maturation of the *fruit* and *seeds* (57). So far as we know, the sole office of the flower and fruit in the vegetable economy is the production of seed. Hence they are termed ORGANS OF REPRODUCTION.

240. Plants begin to bear flowers at a nearly determinate period for each species; which is dependent partly upon constitutional causes that we are unable to account for, and partly upon the requisite supply of nutritive matter in their

system. For, since the flower and fruit draw largely upon the powers and nourishment of the plant, while they yield nothing in return, fructification is an exhaustive process, and a due accumulation of food is requisite to sustain it.* Annuals flower in a few weeks or months after they spring from the seed, when they have little nourishment stored up in their tissue; and their lives are destroyed by the process (57): biennials flower after a longer period, rapidly exhausting the nourishment accumulated in the root during the previous season, and then perishing (58); while shrubs and trees do not commence flowering until they are sufficiently established to endure it. The exhaustion consequent upon flowering, however, is often exhibited in fruit-trees, which, after producing an excessive crop (especially of late fruits, such as apples), sometimes fail to bear the succeeding year. And when the crop of one year is destroyed, the nourishment which it would have consumed accumulates, and the tree may bear more abundantly the following season.

241. The actual consumption of nourishment in flowering may be shown in a variety of ways; as by the rapid disappearance of the farinaceous store in the roots of the

---

* When the branch of a fruit-tree, which is sterile or does not perfect its blossoms, is *ringed* or *girdled* (by the removal of a narrow ring of bark), the elaborated juices, being arrested in their downward course, are accumulated in the branch, which is thus enabled to produce fruit abundantly; while the shoots that appear below the ring, being fed only by the crude ascending sap, do not bear flowers, but push forth into leafy branches. So the flowers of most trees and shrubs that bear large or fleshy fruit are produced from lateral buds, resting directly upon the wood of the previous year, in which a quantity of nutritive matter is deposited. So, also, a seedling shoot, which would not flower for several years if left to itself, blossoms the next season when inserted as a graft into an older trunk, from whose accumulated stock it draws.

Carrot, Beet, &c., when they begin to flower, leaving them light, dry, and empty; and from the rapid diminution of the sugar in the stalk of the Sugar-cane (as also in that of Maize) at the same period. The stalks are therefore cut for making sugar just before the flowers expand, as they then contain the greatest amount of saccharine matter.

242. The consequences of this exhaustion upon the duration of plants have already been adverted to (57 – 59, 129). They are further illustrated by the facility with which annuals may be converted into biennials, or their life prolonged indefinitely, by preventing their flowering; while, whenever they bear flowers and seed, whether during the first or any succeeding year, they commonly perish. So a common annual Larkspur has produced a double-flowered variety in the gardens, which bears no seed, and has therefore become a perennial. So, also, cabbage-stumps, which are planted for seed, may be made to bear heads the second year by destroying the flower-shoots as they arise; and the process may be continued from year to year, thus converting a biennial into a kind of perennial plant. The effect of flowering upon the longevity of the individual is strikingly shown by the Agave, or Century-plant, — so called because it flowers in our conservatories only after the lapse of a hundred, or at least a great number of years; while in its native sultry clime it generally flowers in the course of five or six years. But whenever this occurs, the sweet juice with which it is filled at the time is consumed at a rate correspondent to the astonishing rapidity with which its huge flower-stalk shoots forth (19), and the whole plant inevitably perishes when the seeds have ripened. So, also, the Corypha, or Talipot-tree, a magnificent oriental Palm, which lives to a great age and attains an imposing altitude (bearing a crown of leaves, each of which are often thirty feet in diameter), flowers only once; but it then bears an

enormous number of blossoms, succeeded by a crop of nuts sufficient to supply a large district with seed; while the tree immediately perishes from the exhaustion consequent upon this over-production.

243. Flowering and fruiting, then, draw largely upon the plant's resources, while they give back nothing in return. In these operations, and perhaps in these alone, do vegetables act as true consumers (like animals, 236), decomposing their own products, and giving back carbonic acid and water to the air, instead of taking these materials from the air. It is in flowering that they actually consume most. In fruiting, although the plant is robbed of a large quantity of nourishment, this is mostly accumulated in the fruit and seed, in a concentrated form, for the future consumption, not of the parent plant, but of the new individual inclosed in the seed. As we may treat of the latter in another place, we have here to contemplate only the real and immediate consumption of nourishment by the flower.

244. This is shown by the action of flowers upon the air, so different from that of leaves. While the foliage withdraws carbonic acid from the air, and restores oxygen (224, 230), flowers take a small portion of oxygen from the air, and give back carbonic acid. While leaves, therefore, purify the air we breathe, flowers contaminate it; though, of course, only to a degree which is relatively and absolutely insignificant.

245. When carbon is consumed as fuel, and by the aid of the oxygen of the air converted into carbonic acid, an amount of heat is evolved, uniformly and directly proportionate to the quantity of carbon consumed, or of carbonic acid produced. The same amount is more slowly generated in the slower decomposition of an equivalent amount of vegetable matter by decay, — a heat which is employed by the gardener when he makes hot-beds of tan or decaying

leaves, — or by the breathing of animals, where it maintains their elevated temperature. The consumption of a given amount of carbon, &c., under whatever form, and whether slowly or rapidly, generates in all cases the very same amount of heat.

246. Now, since flowers consume carbon and produce carbonic acid, acting in this respect like animals, they ought to evolve heat in proportion to that consumption. This, in fact, they do. The evolution of heat in blossoming was first observed by Lamarck, about seventy years ago, in the European Arum, which, just as the flowers open, "grows hot," as Lamarck stated, "as if it were about to burn." It was afterwards shown by Saussure in a number of flowers, such as those of the Bignonia, Gourd, and Tuberose, and the heat was shown to be in direct proportion to the consumption of the oxygen of the air, or in other words, of the carbon of the plant. The increase of temperature, in these cases, was measured by common instruments. But now that thermo-electric apparatus affords the means of measuring variations inappreciable by the most delicate thermometer, the heat generated by any ordinary cluster of blossoms may be detected. The phenomenon is most striking in the case of some large tropical Aroideous plants, where an immense number of blossoms are crowded together and muffled by a kind of hood, or spadix (265), which confines and reverberates the heat. In some of these, the temperature rises at times to twenty or even fifty degrees (Fahrenheit) above the surrounding air.*

---

* This increase of temperature occurs daily from the time the flowers open until they fade, but is most striking during the shedding of the pollen. At night the temperature falls nearly to that of the surrounding air; but in the course of the morning the heat comes on, as it were, like a *paroxysm of fever*, attaining the max-

247. The source of the heat in flowering is evident. As to its object, we cannot say whether its production is the immediate end in view, and the plant burns some of its carbon merely as fuel, or whether the evolution of heat and the formation of carbonic acid are incidental consequences of certain necessary transformations. We have remarked (243) that the principal *consumption* takes place in the flower; and that a store is laid up in the fruit and seed. But much even of this is consumed, with the evolution of heat, when the seed germinates. It may be said, therefore, that in the Century-plant (242), which, after living an hundred years, consumes itself for the benefit of its offspring, who literally rise from its ashes, we have the realization of the fabled Phœnix!

248. There is another condition, which, if not essential to the production of flowers, exerts an important influence. When plants are in continual and luxuriant growth, rapidly pushing forth leafy branches, they seldom produce flower-buds. Our fruit-trees, in very moist seasons, or when cultivated in too rich a soil, often grow luxuriantly, but do not flower. The same thing is observed when our northern fruit-trees are transported into tropical climates. On the other hand, whatever checks this luxuriance, without affecting the health of the individual, causes blossoms to appear earlier and more abundantly then they otherwise would do. It is for this reason that transplanted fruit-trees incline to flower the first season after their removal, though they may

---

imum, day after day, very nearly at the same hour of the afternoon, and gradually declining towards evening. In ordinary cases the heat of flowering is absorbed by the vaporization of the sap and the exhalation of oxygen by the foliage; so that the actual temperature of a leafy plant in summer is lower than that of the atmosphere.

not blossom again for several years. A season of comparative rest is essential to the transformation by which flowers are formed. It is in autumn, or at least after the vigorous vegetation of the season is over, that our trees and shrubs, and most perennial herbs, produce the flower-buds of the ensuing year.

249. The requisite annual season of repose, which in temperate climes is attained by the lowering of the temperature in autumn and winter, is scarcely less marked in many tropical countries, where winter is unknown. But the result is brought about, in the latter case, not by cold, but by excessive heat and dryness. The Cape of Good Hope, or the Canary Islands may be taken as illustrations. In the Canaries, the growing season is from November to March, — the winter of the northern hemisphere, — their winter also, as it is the coolest season, the mean temperature being 66° (Fahrenheit). But the rains fall regularly and vegetation is active; while in summer, from April to October, it very seldom rains, and the mean temperature is as high as 73°. During this dry season, when the scorching sun reduces the soil nearly to the dryness and consistency of brick, ordinary vegetation almost completely disappears; and the Fig-Marigolds, Euphorbias, and other succulent plants, which, fitted to this condition of things, alone remain green, not unaptly represent the Firs and other evergreens of high northern latitudes. The dry heat there brings about the same state of vegetable repose as cold with us. The roots and bulbs then lie dormant beneath the sun-burnt crust, just as they do in our frozen soil. When the rainy season sets in, and the crust is softened by moisture, they are excited into growth under a diminished temperature, just as with us by heat; and the ready-formed flower-buds are suddenly developed, and at once clothe the arid waste with a profusion of blossoms. This season of interruption

to growth, produced either by cold or dryness, occurs, in a more or less marked degree, through every part of the world.

250. These considerations explain the operations of *forcing* plants, by which we are enabled to obtain in winter the flowers and fruits of summer. The gardener accomplishes these results principally by skilful alterations of the natural period of repose. He gives the plant an artificial period of rest by dryness at the season when he cannot command cold, and then, by the influence of heat, light, and moisture, which he can always command, causes it to grow at a season when it would have been quiescent. Thus he retards or advances, at will, the periods of flowering and of rest, or in time completely inverts them.

CHAPTER VIII.

OF THE INFLORESCENCE.

251. THE term INFLORESCENCE is used to designate the arrangement of flowers upon the stem or branch.

252. The flower, like the branch, is evolved from a bud. Flower-buds and leaf-buds are often so similar in appearance that it is difficult to distinguish one from the other before their expansion. The most conspicuous parts of the flower are so obviously analogous to the leaves of a branch, that they are called in common language the leaves of the flower. Such a flower as the Double Camellia appears as if composed of a rosette of white or colored leaves, resembling, except in their color and greater delicacy, the clusters of leaves which crown the offshoots of such plants

as the House-leek, &c. We may therefore naturally consider a flower-bud as analogous to a leaf-bud; and a flower, consequently, as analogous to a short, leafy branch.

253. This analogy is confirmed by the position which flowers occupy. Whatever views may be entertained respecting the nature of flowers, it is certain that they appear at the same situations as ordinary buds, and at no other. They have the same relation to the stem or flower-stalk which bears them, that leaf-buds have to the stem or branch from which they arise; that is, they occupy the extremity of the stem or branch, and the axil of the leaves (69, 71).

254. As the arrangement of the buds governs the whole disposition and symmetry of the branches (73), so the same plan is followed in the arrangement of the blossoms. The flower-stalks are merely the last term of ramification. The almost endless variety of modes in which flowers are clustered upon the stem, many of them exhibiting the most graceful of natural forms, all implicitly follow the general law which has controlled the whole development of the vegetable from its very germination. We have, throughout, merely buds terminating the stem and branches, or buds from the axil of the leaves.

255. The simplest kind of inflorescence is, of course, that of a *solitary* flower, — a single flower-stalk bearing a single flower; as in the Erythronium (Fig. 1025), and the Brasenia (Fig. 383). The naked stalk which supports the flower is termed the PEDUNCLE. If the flower is not raised on a proper stalk, it is said to be sessile.

256. In both of the examples just adduced, the flower is solitary; but there is a difference in one respect. In Fig. 1025, the flower terminates the stem; it stands in the place of a terminal bud. In Fig. 383, it arises from the axil of a leaf, or represents an axillary bud. These two cases, in fact, exhibit the two types (reduced to the greatest sim-

plicity), to the one or the other of which all the forms of inflorescence belong.

257. We may begin with the second of these plans; in which the flowers all spring from axillary buds, while the terminal bud, developing as an ordinary branch, continues the stem or axis. The stem in such case may continue to elongate, and produce a flower in the axil of every leaf, until its powers are exhausted; as in Gratiola (Fig. 731), and in Gerardia (Fig. 735).

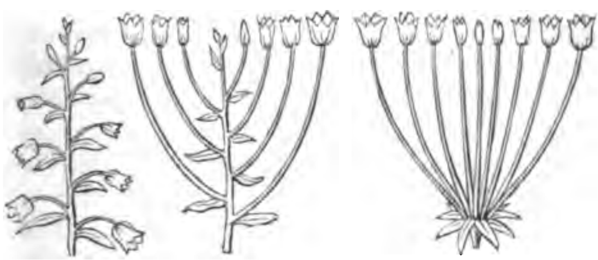
258. When the leaves which have flowers developed in their axils are reduced in size, or changed in appearance from the ordinary leaves of the plant, they are termed BRACTS; the flower-bearing portion of the stem or branch is then considered to belong to the inflorescence; the stalk, or main continuation of the stem, is called the PEDUNCLE, and the separate stalks which support each single flower receive the name of PEDICELS. The reduced leaves or bracts, at the base of the pedicels, are often minute or inconspicuous, and sometimes they entirely disappear. That part of the general peduncle along which flowers are borne is occasionally termed the *axis of the inflorescence*, and sometimes the RACHIS.

259. When a single flower is produced in the axil of each bract, supported on a pedicel, while the axis continues to lengthen, a RACEME is formed; as in Fig. 151, and in a cluster of Currants, &c. The lowest flowers of a raceme, being evidently the oldest, are the first to expand, and the others follow in regular succession, from the base to the summit, as in the Wild Black-Cherry (Fig. 156), Pyrola (Fig. 675), the Poke (Fig. 865), &c. Indeed, the lower flowers often produce, or (as in the Snowberry, Symphoricarpus racemosus) even ripen, their fruit, before the summit has ceased to grow and develope new flowers.

260. A CORYMB (Fig. 152, 159) is the same as a raceme

with the lower pedicels elongated, so as to form a level-topped or slightly convex bunch of flowers; as in Cratægus or Wild Thorn, &c.

261. An UMBEL (Fig. 153) only differs from a corymb in having all the pedicels arising from the same point; the general peduncle, in this case, bearing several flowers without any perceptible elongation of the axis of inflorescence (258). Ex. Primula pusilla (Fig. 692).



262. A corymb being evidently the same as a raceme with a short axis, and an umbel the same as a corymb with a still shorter axis, it is evident that the outer flowers of an umbel or corymb correspond to the lowermost in the raceme, and that these will first expand, the blossoming proceeding regularly from the base to the apex, or (which is the same thing) from the circumference to the centre. This mode of development uniformly takes place when the flowers arise from axillary buds, as in all these cases (257–271); on which account this general kind of inflorescence is said to be *centripetal.*

263. In all the foregoing cases, the flowers are raised on stalks, or pedicels. When these are wanting, or very short, the plan remains the same, but the appearance is somewhat different.

FIG. 151–153. Diagrams of a simple raceme, corymb, and umbel.

264. Thus a Spike is the same as a raceme, except that the flowers are *sessile*, or destitute of stalks; as in the Plantain (Fig. 701), Polygonum (Fig. 861), the Saururus (Fig. 898), &c.

265. A Spadix is a spike enveloped by a large bract or modified leaf. Ex. Calla palustris (Fig. 154), the cultivated Calla Æthiopica, Arum triphyllum, or Indian Turnip (Fig. 155), the Skunk Cabbage (Fig. 983).

154 155

157 158 159

266. An Ament, or Catkin, is merely a particular kind of spike with scaly bracts, crowded together, the whole usually falling off, after flowering, in a single piece; as in the Willow (Fig. 944), the Poplar, the Birch (Fig. 936), and many other trees.

267. The Capitulum, or Head, a term which is applied to a globular cluster of sessile flowers, as in the Button

FIG. 154-159. Forms of inflorescence. 154, 155. A spathe and spadix. 156. A raceme. 157. A cyme. 158. A panicle. 159. A corymb.

Bush, or Cephalanthus (Fig. 632), may be conceived to arise from the shortening of the pedicels either of an umbel (Fig. 153), or a corymb (Fig. 152). It bears the same relation to these, that the spike does to the raceme. It differs from the spike only in its very short axis. In all these varieties, the blossoms necessarily expand from the base to the apex, or from the circumference to the centre (262).

268. The base both of the head and the umbel is frequently furnished with a number of imperfect leaves or bracts, crowded together, or forming a whorl (182), termed an Involucre. The involucre assumes a great variety of forms; sometimes resembling a calyx; and sometimes (as in Cornus Florida, or common Dogwood, and C. Canadensis, Fig. 160), becoming petal-like, and much more showy than the blossom itself. It is, however, distinguished from the calyx or corolla by including a number of flowers; yet in the Mallow and Hibiscus (Fig. 463), and some other plants, the involucre forms a kind of outer calyx to each flower.


160 a

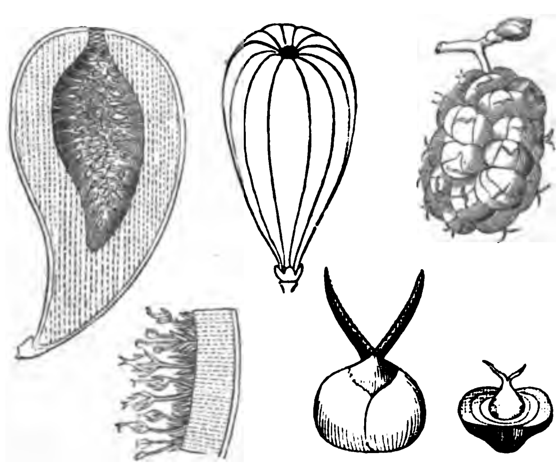
269. The axis, or rachis (258), of a head is called the Receptacle. Frequently, instead of being at all prolonged, it is flat or depressed, and dilated horizontally, so as to allow a large number of flowers to stand on its level surface; as

FIG. 160. Cornus Canadensis; with its petal-like four-leaved involucre surrounding a head of flowers: *a*, a separate flower enlarged.

in the Sunflower, and in similar plants. What were called *compound flowers* by the older botanists, such as the Sunflower, Aster, Marigold, &c., are heads of this kind, containing a smaller or larger number of flowers, crowded together on the receptacle (or dilated branch), and surrounded by an involucre (Fig. 654). Not unfrequently the separate flowers are also furnished with bracts; as in the Sunflower, Rudbeckia, Coreopsis, &c., when these receive the name of PALEÆ, or CHAFF (Fig. 660).

270. The FIG presents a case of very singular inflorescence (Fig. 161, 162), the flowers being inclosed within the fleshy receptacle, which is hollow and nearly closed at the top. The magnified slice (Fig. 163) shows that the inner surface is lined, not with mere seeds, as is commonly sup-

162 161 164



163 a b

FIG. 161. A fig. 162. A vertical section enlarged. 163. A thin slice of the same magnified.

FIG. 164. The Mulberry in fruit: *a*, one of the component flowers, magnified: *b*, one of the flowers with a section of the juicy floral envelopes.

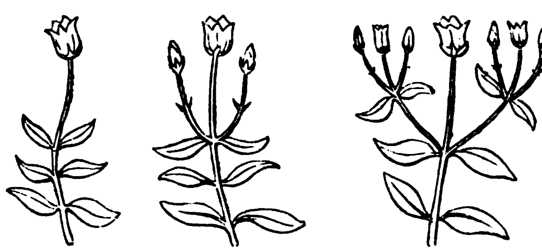
posed, but with a multitude of small blossoms. The fig is therefore something like a mulberry (Fig. 164) turned inside out.

271. In all the cases yet mentioned, the flower-clusters are simple; the lateral buds each developing only a single flower. But the lateral flower-stalks may subdivide, just like ordinary branches; when the inflorescence becomes compound. The modifications produced by a second branching of the inflorescence are readily understood. If the branches of a raceme are prolonged, and give rise to other flowers on pedicels similarly arranged, a *compound raceme* is produced; but if they branch irregularly, a PANICLE (Fig. 158) is formed. A compact panicle, of a somewhat pyramidal form, but contracted at the base, is called a THYRSUS; as in the Lilac, the Horse-Chestnut (Fig. 500), a bunch of grapes, &c. A corymb, the branches of which are similarly subdivided, forms a *compound corymb;* and an umbel, where the branches (often called *rays*) bear smaller umbels at their apex, is termed a *compound umbel* (Fig. 606); examples of which occur in almost all the species of the order Umbelliferæ. For these secondary umbels, a good English name has been employed by Dr. Darlington, that of UMBELLETS. Their involucre, when they have any, is distinguished from that of the principal umbel by the name of INVOLUCEL.

272. In description, it is often necessary to distinguish between the bracts on the branches of the inflorescence, and those at the base of the primary branches; in which case the former are termed BRACTEOLES, or BRACTLETS; but there is no real limit, either between bractlets and true bracts, or between bracts and true leaves.

273. In the other principal mode of inflorescence (256), the solitary or primary flower arises from a terminal bud, as in Fig. 165. Further elongation of the stem is of course

impossible; and in many plants no additional development takes place. This, however, is not necessarily the case; for the accumulation of nourishment in the stem after the production of the terminal flower often causes buds to develope in the axils of the upper leaves or bracts, in the form either of leafy or of flower branches. If leafy branches are produced, these continue the stem beyond the flower, which becomes lateral and to appearance axillary when only one branch is formed (as in Arenaria lateriflora, Fig. 446), or is left in the forks of the branches when two arise, one in the axil of each of the upper pair of leaves, as in many Chickweeds. But these branches are at length terminated, like the original stem, with a single flower, and if they again branch, the branchlets also terminate in a flower; so that all the flowers arise from terminal buds. But if the buds of all the upper axils appear in the form of single flowers, a kind of reversed spike or raceme is produced (according as the flowers are sessile or on peduncles), which *blossoms from the summit downwards*, the terminal flower being the oldest. Most frequently a single peduncle arises from the axil of each leaf of the uppermost pair (as

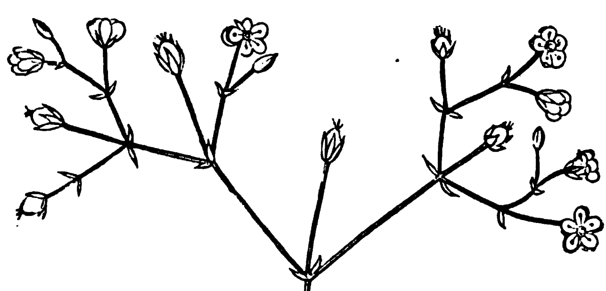


165 166 167

in Fig. 166), furnished with a pair of bracts in some part of its length, and terminated by a single flower; so that we have three flowers at the summit of the stem; one terminal,

FIG. 165-167. Diagrams of centrifugal inflorescence.

which is known by its flowering earliest, and by having no bracts on its peduncle, and one belonging to the axil of each leaf; the latter opening a little later, and having a pair of bracts on the peduncle. If the development continues, a flower is produced in the axil of each of these bracts, so that the branch likewise bears three flowers, of which the middle one is oldest, and the lateral furnished with bracts on their peduncles, as in Fig. 167. This may go on until the powers of the stem are exhausted, or until the lateral peduncles (at length reduced to single internodes) are produced without bractlets, when no more branches can arise. Since the central flower, being the oldest, is the first to expand, and the central ones of each cluster precede the lateral ones, this kind of inflorescence is called *centrifugal.* It is also termed *cymose*, the arrangement of the flowers being the same as in the proper cyme of the older authors. The successive production of flower-branches after the original terminal flower has expanded, or even ripened its fruit, in the Chickweed, and other plants of that family



168

(as in Arenaria stricta, Fig. 168), enables us to study this mode of inflorescence to advantage. The true, or original Cyme (Fig. 157), as in the Laurustinus, and all the species

FIG. 168. Cymose, or centrifugal inflorescence of Arenaria stricta.

of Viburnum, Elder, Hydrangea, &c., has the same structure; except that the whole transformation has taken place, and all the numerous flower-buds are completely formed, before any of them are expanded. The cyme is usually broad and flat-topped, like a corymb; from which it is at once distinguished by the mostly regular three-forked ramification, and by the central flowers of each cluster being the first to expand. The central clusters, also, representing the proper summit of the stem, being earliest in blossom, and the lateral ones following in exactly the reverse order from that of the corymb (Fig. 152), the general expansion is *centrifugal*, that is, proceeds from the centre to the circumference.

274. A cyme with the flowers crowded and nearly sessile is called a FASCICLE; as in the Sweet William, and in Fig. 645; or, when much crowded and like a head, a GLOMERULE.

275. Various modifications of both forms of inflorescence, but especially of the centrifugal or cymose, arise from irregular development, or the suppression of parts, such as the non-appearance sometimes of the central flower, or often of one of the lateral branches at each division; as in the ultimate ramifications of Fig. 168, where one of the lateral pedicels is wanting. When this deviation is completely carried out, that is, when one of the side branches regularly fails to appear, the cyme is apparently converted into a

FIG. 169, 170. Plans of scorpioid or helicoid cymes.

kind of one-sided raceme, and the flowers seem to expand from below upwards, or centripetally. The diagram, Fig. 169, when compared with Fig. 168, explains this anomaly. The place of the axillary branch which fails to develope at each ramification is indicated by the dotted lines. Cases like this occur in several Hypericums, and in some other opposite-leaved plants. An analogous case occurs in many alternate-leaved plants; where the stem, being terminated by a flower, is prolonged by a branch from the axil of the uppermost leaf, or bract: this, bearing a flower, is similarly prolonged by a secondary branch, that by a third, and so on; as is shown in the diagram, Fig. 170. Such forms of inflorescence — which we may observe in most Sedums, in the Forget-me-not (Fig. 759), and perhaps in the whole family of Boraginaceæ — imitate the raceme so nearly that they have commonly been considered as of that kind. They are perfectly distinguishable, however, by the position of the flowers exactly *opposite* the leaf or bract; while in the raceme, and in every modification of centripetal inflorescence, the flowers necessarily spring from the axils of the bracts (257 – 259). But if the bracts disappear, the true nature of such clusters is not readily made out. For obvious reasons, the undeveloped portion is usually coiled in a spiral or *circinate* manner, gradually unrolling as the flowers open. Hence they are named *scorpioid* or *helicoid cymes*.

276. The cyme, raceme, head, &c., as well as the one-flowered peduncle, may be produced, either at the extremity of the stem or leafy branch (*terminal*), or in the axil of the leaves (*axillary*). A peduncle which arises from the stem at or beneath the surface of the ground is called a SCAPE (Fig. 397, 403, 424, 437, &c.), or sometimes a *radical peduncle*.

277. In some species of Solanum, &c., the peduncles

arise from the stem at a short distance above the axils of the leaves; an apparent deviation produced by the cohesion of the lower part of the peduncle with the stem. In Limnanthemum (Fig. 820), the flowers are borne on the long petioles, an anomaly which can only be explained by supposing the peduncle and petiole to have grown together for nearly their whole length. In Tilia (Bass-wood or Linden, Fig. 467), the peduncle is evidently united with the midrib of the floral leaf.

278. In the Vine (Fig. 171, where the tendrils take the place of flower-stalks) and the Poke, or Phytolacca (Fig. 866), the peduncles are situated exactly opposite the leaves, instead of being in their axils; an anomaly which at first sight appears very puzzling. But in these cases we observe that the uppermost raceme, or thyrsus, or tendril, terminates the stem; and that the latter is continued by the growth of the axillary bud situated between the petiole and the peduncle; the branch thus formed, assuming the same direction as the main stem, and appearing to be its continuation, throws the peduncle to the opposite side: this process, repeated at every flower-branch, produces the anomaly in question. It is a case quite similar to that which Fig. 170 is intended to illustrate, except that the peduncles branch or bear clusters, instead of single flowers.

279. Sometimes a combination of the two principal modes of inflorescence is observed, the general axis developing in one way, but the separate clusters of flowers in the other. Thus the heads of all the Compositæ (Fig. 654, &c.) are *centripetal*, the flowers expanding regularly from the margin or circumference to the centre; while the branches that bear the heads are developed in the *centrifugal* mode, the terminal or central heads first coming into flower. This is exactly reversed in all Labiatæ (plants of the Mint tribe); where the stem developes in the centripetal

mode, the axillary clusters of flowers being produced in the form of a general raceme or spike which blossoms from below upwards; while the flowers of each cluster form a cyme, and expand in the centrifugal manner.

280. The reduced cymes (or CYMULES) of Labiatæ are usually close and compact, and being situated one in each axil of the opposite leaves, they frequently form clusters which surround the stem, like a whorl or verticil: hence such flowers are often said to be *whorled* or *verticillate*, which is not really the case, as they all spring from the axils of the two leaves. A reduced cyme of this kind is sometimes termed a VERTICILLASTER. Ex. Leonurus, or Catnip, Marubium, or Horehound. True whorled flowers occur only in some plants with whorled leaves, as in Hippuris (Fig. 581), and the Water Milfoil.

171

FIG. 171. The Grape-Vine, illustrating the case of branches (tendrils) opposite the leaves.

CHAPTER IX.

OF THE FLOWER.

§ 1. The Flower in general, and its component Parts.

281. Having glanced at the circumstances which attend and control the production of flowers, and considered the laws which govern their arrangement, we have next to inquire what the flower is composed of.

282. The flower assumes an endless variety of forms in different species, so that it is very difficult properly to define it. The name was earliest applied, as it is still in popular language generally applied, to the delicate and gaily-colored leaves of petals, so different from the sober green of the foliage. But the petals, and all these bright hues are entirely wanting in many flowers, while ordinary leaves sometimes assume the brilliant coloring of the blossom. The stamens and pistils are characteristic organs of the flower; but sometimes one or the other of these disappear from a particular flower, and both are absent from full *double* Roses, Camellias, &c., in which we have only a regular cluster, or rosette, of delicate leaves.

283. We must commence, therefore, by assuming some particular example as a *type* or *pattern*. The pattern flower, evidently, should not be that which is reduced to the greatest degree of simplicity, nor that which exhibits the highest complexity; but one which presents all the organs of a perfect flower in the most distinct and simple state. That the flower which we take for present illustration fulfils all the conditions of such a type will presently appear.

284. The organs of the flower are of two sorts, namely,

1st, its leaves or envelopes; and 2d, those peculiar organs which ordinarily have no resemblance to leaves. The former are of course *exterior*, or *lower* than the latter, which in the bud they inclose.

285. The FLORAL ENVELOPES are commonly distinguished into two kinds, or occupy two rows, one above or within the other. The lower or outer row is termed the CALYX, and commonly exhibits the green color of ordinary leaves (Fig. 172, *a*). The inner row, which is usually of more delicate texture and brighter hue, and forms the most showy part of the blossom, is named the COROLLA (Fig. 172, *b*). The several parts or leaves of the corolla are called PETALS; and the leaves of the calyx have received the analogous name of SEPALS.

286. But when the floral envelopes consist of only one whorl of leaves, they are called *calyx*, whatever be their appearance, texture, or color. For, since the calyx is frequently delicate and petal-like (in botanical language *petaloid* or *colored*), and the corolla sometimes greenish or leaf-like, the only real difference between the two is, that the calyx represents the outer, and the corolla the inner series; and even this distinction becomes more or less arbitrary when either, or both, of these organs consist of more than one row or whorl. The floral envelopes are collectively termed the PERIANTH (*perianthium* or *perigonium*): but this name is seldom used, except in cases where the calyx and corolla are not satisfactorily distinguishable, or where the existence of two series is uncertain; as in very many Endogenous plants.

287. As there are two sorts of floral envelopes, so the essential organs they inclose are likewise of two kinds, and occupy two rows, one within the other. The first of these, those next within the petals, are the STAMENS (Fig. 172, *c*). A stamen consists of a column or stalk, called the FILA-

MENT (Fig. 174, *a*), which bears on its summit a rounded body, or case, termed the ANTHER (*b*), filled with a powdery substance called POLLEN. The older botanists had no general term for the stamens taken collectively, analogous to that of corolla for the entire whorl of petals, and of calyx for the whorl of sepals. A name has however recently been proposed for the ***staminate system*** of a flower, which it is occasionally convenient to use; that of ANDRŒCIUM.

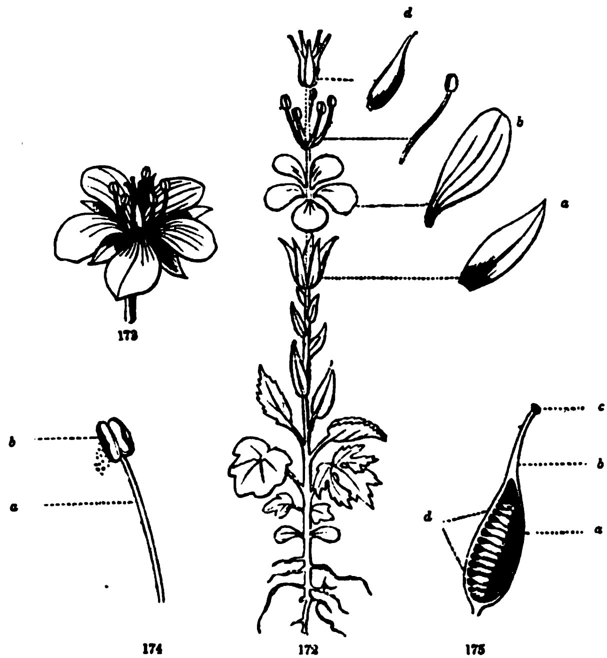


FIG. 172. Ideal plan of a plant, with the simple stem terminated by a pattern flower, like that shown in Fig. 173; the different sets of organs separated to some distance from each other, to show the relative situation of the parts; one of each, namely, *a*, a sepal, *b*, a petal, *c*, a stamen, and *d*, a pistil, also shown enlarged.

FIG. 174. A stamen: *a*, the filament; *b*, the anther, discharging pollen.

FIG. 175. Vertical section of a pistil: *a*, the cavity of the ovary, containing *d*, ovules or rudiments of seeds; *b*, the style, tipped by *c*, the stigma.

288. The remaining, or seed-bearing organs, which occupy the centre or summit of the flower, for whose protection and perfection all the other parts of the flower are in some way subservient, are termed the PISTILS (Fig. 172, *d*). To them the collective name of GYNÆCIUM has been applied.

289. A pistil is distinguished into three parts; namely, 1st, the OVARY (Fig. 175, *a*), the hollow portion at the base which contains the OVULES, or bodies destined to become seeds; 2d, the STYLE (*b*), or columnar prolongation of the apex of the ovary; and 3d, the STIGMA (*c*), or termination of the style, sometimes a mere point, but which often appears as a small knob, or in some other form. The cavity of the ovary is called its *cell.*

290. All the organs of the flower are situated on, or grow out of, the apex of the flower-stalk, into which they are said, in botanical language, to be *inserted*, and which is called the TORUS, or RECEPTACLE. It is the axis of the flower, to which the floral organs are attached (just as leaves are to the stem); the calyx at its very base; the petals just within or above the calyx; the stamens just within the petals; and the pistils within or above the stamens.

291. Such is the structure of a complete and regular flower. The calyx and corolla are termed *protecting organs.* In the bud, they envelope the other parts: the calyx sometimes forms a covering even for the fruit; and when it retains its leaf-like texture and color, it digests the sap of the plant in the same manner as true leaves: the corolla elaborates honey or other secretions, for the nourishment, as is supposed, of the stamens and pistils. But neither the calyx nor corolla is essential to a flower, one or both being not unfrequently wanting, or very minute. The stamens and pistils are, however, *essential organs* of the flower, since both are necessary to the production of seed. But

the two are not always present in the same flower, as will hereafter be seen.

§ 2. Of the Structure of the Flower, and its various Modifications.

292. Our pattern flower (Fig. 172, 173) is *complete*, for it possesses all the organs or parts of the flower. It is *simple*, for it exhibits only one set or row of each kind. It is perfectly *regular* and *symmetrical*, the number of sepals, petals, stamens, and pistils being the same throughout, namely, five, and the size and form of the members of each set being uniform. A section across the flower or flower-bud would present the same ground-plan as in Fig. 177.

293. From this *type*, moreover, all of the almost numberless variety of forms which flowers exhibit may readily be deduced. They all result from certain variations in the details of the plan, — variations such as are known to affect ordinary branches and leaves, and are perfectly accordant with the recognized laws and phenomena of vegetation; — such, for instance, as the increase of the number of parts in each set; the production of two or more rows of some or all of the floral organs; or, on the other hand, the diminution of parts, or their cohesion in a variety of modes, and to a greater or less extent, into one mass. Taking it for granted, therefore, that all flowers are constructed upon one and the same general plan, the botanist, having chosen the type which represents his ideal conception of the simplest and most perfect flower, applies it to all the cases which present themselves, and particularly to the elucidation of those blossoms in which the true structure and symmetry are more or less masked or obscured. Its application, like the touch of the disenchanting spear of Ithuriel, at once reveals the primitive character of the most disguised and complicated forms of vegetable organization.

294. The principal causes which, upon our supposition, interfere with, and more or less disguise, the typical and symmetrical structure of the flower, are:

1st. The production of one or more additional whorls or sets of some of the floral organs.

2d. The union of the parts of the same set by the cohesion of their contiguous margins.

3d. The cohesion of the adjacent parts of different sets.

4th. The non-production (suppression) of some of the sets altogether.

5th. The non-production, or abortion, of some of the parts of one or more sets of organs.

6th. The unequal development, or unequal union of different parts.

7th. Deviations or changes in the form of the receptacle or axis of the flower.

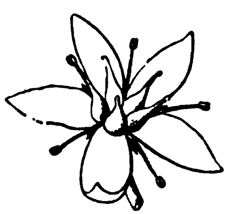
295. Several of these deviations from the typical state of the flower do not interfere with its symmetry; a flower being termed *symmetrical* when there is an equal number of parts in each series. The regularity of the flower is affected by the fifth and sixth of the causes enumerated, a flower being called *regular* when the several parts of the same set of organs are uniform in size and shape; and *irregular*, when this is not the case.

296. Since it can hardly be doubted that the flower is constructed upon the same general plan in all the species of the same natural family of plants, we may draw some illustrations of our view from a single group of nearly related plants. The order Crassulaceæ affords the best examples of flowers most conformable to our assumed pattern, which, indeed, is actually realized in its typical genus, Crassula. In this case (Fig. 176), we have a calyx of five sepals, a corolla of five petals alternate with the former, an andrœcium (287) of five stamens alternating with the petals,

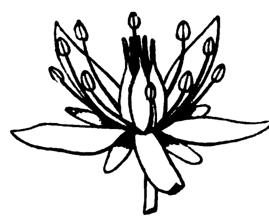
and a gynæcium (288) of five pistils, which are alternate with the stamens; and all the parts are regular and symmetrical, and also distinct and free from each other; except that the sepals are somewhat united at the base, and the petals and stamens slightly connected with the inside of the calyx, instead of manifestly arising from the receptacle or axis, just beneath the pistils. The arrangement of the organs is more distinctly exhibited in the annexed diagram, or ground-plan (Fig. 177), representing a horizontal section of the unopened flower; the exterior row of lines being of course intended for the whorl of sepals; that within, for the petals; the five small dots, for the stamens; and the central series, for the pistils.

297. Other plants of the same family exhibit several classes of deviations from this pattern. Thus the Sedums, or Stone-crops (Fig. 178), vary from the type merely by having twice as many stamens as there are petals or sepals.

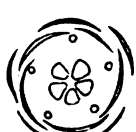
176



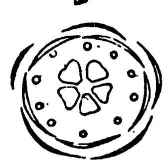
178



177



a



179

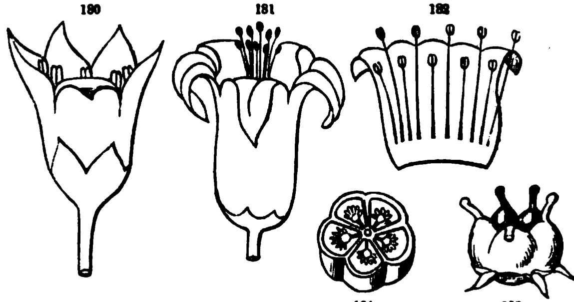
FIG. 176. Flower of a Crassula. 177. Plan of a cross section of the flower-bud, to show the relative position of its parts.

FIG. 178. Flower of a Sedum: *a*, a separate pistil. 179. Cross section of the flower-bud.

This deviation is owing, as we suppose, to the production of an additional set or whorl of stamens; and the supernumeraries may be recognized by their shorter filaments, as well as their position before the petals (alternate with the first, as is seen in the ground plan, Fig. 179). It therefore illustrates the first class of the deviations enumerated in paragraph 294. A third genus (Rochea) exhibits the same *normal* flower as Crassula, except that the contiguous edges of the petals slightly cohere about half their length, although a little force suffices to separate them: in another (Grammanthes, Fig. 180), the petals are firmly united into a tube for more than half their length; and so are the sepals, likewise. These accordingly illustrate the second class of deviations from primitive simplicity. Next, the genus Cotyledon (Fig. 181) presents both of these cases together in one flower; that is, its sepals and petals are each partly united in a cup or tube, as in Grammanthes; and the stamens are doubled, as in Sedum. And the same instance also exhibits the third class of deviations, namely, the cohesion of different sets of organs with each other; for the stamens are coherent at their base with the corolla, out of which they therefore seem to arise, as is shown in Fig. 182, where the corolla is laid open and displayed. The pistils, although ordinarily exhibiting a strong tendency to unite, are perfectly distinct in all these cases, and indeed throughout the order, with two exceptions; one of which is seen in Penthorum, where the five ovaries (Fig. 183) are united below into a solid body, while their summits, as well as the styles, are separate. The same plant also furnishes an example of the non-production (*suppression*) of one whorl of organs, that of the petals; which, although present in some specimens, are altogether wanting in others. A remarkable instance of the *suppression* of one part out of each whorl of floral organs is observed in Sedum ternatum (a common

Stone-crop in gardens), and a few other North American species; where the first flower which the stem or branch produces has five sepals, five petals, ten stamens, and five pistils, in the ordinary manner; but nearly all the subsequent flowers exhibit only four sepals, four petals, eight stamens (four in each whorl), and four pistils. Again, assuming the number of parts in each whorl to be *normally* five in this order, we notice a constant reduction in Tillæa, where the whorls consist of only three or four parts; and an increase in Sempervivum (the House-leek), in which the sepals, petals, and pistils vary from six to twenty, and the

180 181 182



184 183

stamens from twelve to forty.* Thus a single group of closely related plants, all evidently constructed on the same pattern, exhibits four or five of the seven classes of deviation above enumerated.

* Terms expressive of the number of parts in a whorl, or set of organs, are sometimes employed in descriptive botany; such as *dimerous*, for a whorl of two parts; *trimerous*, for a whorl of three; *tetramerous*, for a whorl of four; *pentamerous*, for a whorl of five; *hexamerous*, for a whorl of six parts, &c.

FIG. 180. Flower of Grammanthes; the sepals and also the petals united by their edges. 181. Flower of Cotyledon, also gamosepalous and gamopetalous. 182. Corolla of the same laid open, showing the two rows of stamens inserted into it. 183. The five pistils of Penthorum united, so as to form a compound ovary. 184. A cross section of the same.

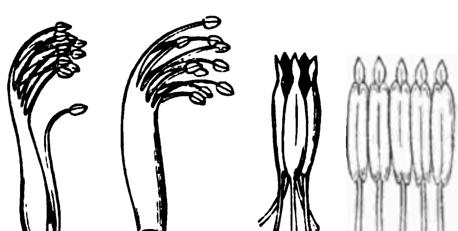
298. These illustrations may readily be extended to different orders, so as to furnish examples of every kind and degree of deviation. Our further account of the structure of the flower may be given in this form; and most of the technical terms which are necessarily employed in describing these modifications may be introduced, and concisely defined, as we proceed.

299. Thus an increased number of whorls of all the floral organs occurs in the Magnolia tribe (Fig. 358); the floral envelopes occupying three or four rows, while the stamens and pistils are very numerous, and compactly arranged on the elongated receptacle. Several whorls of stamens and pistils are also produced in Ranunculus (Fig. 347, &c.), Anemone, and most plants of the same family; while in the Water-Lily (Fig. 393), the floral envelopes and stamens occupy several rows; and a multiplication of the stamens occurs in various plants; as in Hypericum (Fig. 442), and the Linden (Fig. 467). When any parts of the flower are inconstant in number, or so numerous that they are not readily counted, they are said to be *indefinite;* and a flower with numerous stamens is also termed *polyandrous.*

300. The union of the parts of the same whorl or set of organs is so frequent, that few cases are to be found in which it does not occur, to a greater or less extent, in some portion of the flower. When the sepals are united, as in Phlox (Fig. 775), Convolvulus (Fig. 792), &c., the calyx is said to be *monosepalous*, or, more correctly, *gamosepalous;* when the petals are united, as in Convolvulus and Phlox, above cited, and all that class of plants, the corolla is said to be *monopetalous*, or *gamopetalous;* the latter being the appropriate term, as it denotes that the petals are united; but the former is in common use, although strictly incorrect, as it implies that the corolla consists of a single petal. The inappropriate names, in these cases, were given long before

the structure was rightly understood. So, also, such a calyx or corolla is said to be *entire*, when the sepals or petals are united to their very summits (as the corolla of Convolvulus), or to be *toothed*, *lobed*, *cleft*, or *parted*, according to the degree in which the union is incomplete; this language being employed just as in the case of the divisions of leaves (155). When the sepals are not united, the calyx is said to be *polysepalous;* and when the petals are distinct, the corolla is said to be *polypetalous;* that is, composed of several petals.

301. The union of the stamens occurs in various ways. Sometimes the filaments are combined, while the anthers are distinct. When thus united by their filaments into one set, they are said to be *monadelphous;* as in Fig. 186. When united by their filaments into two sets, they are *diadelphous* (Fig. 185), as in most of the Pea tribe (Leguminosæ), where nine stamens form one set and the tenth is solitary; and in Dielytra (Fig. 405), where the six stamens are equally combined in two sets. When united or arranged in three sets or parcels, they are said to be *triadelphous*, or if in several, *polyadelphous;* as in Hypericum (Fig. 442), &c. In other cases, the filaments are distinct, or nearly so, and the anthers united into a ring; as in the vast order Com-



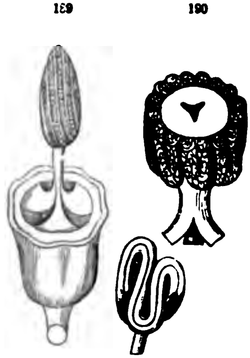
185 186 187 188

FIG. 185. Diadelphous stamens (9 and 1) of a common plant of the Pea tribe. 186. Monadelphous stamens of the Lupine. 187. Syngenesious stamens of a Composite flower. 188. The tube of anthers of the latter laid open.

positæ, or class Syngenesia of the Linnæan artificial system; when the stamens are said to be *syngenesious* (Fig. 187, 188). Again, in Lobelia, not only are the anthers syngenesious, but the filaments are also combined into a tube for the greater part of their length (Fig. 656). The same thing is seen in the Gourd tribe (Fig. 189, 190), where the long and sinuous anthers are besides usually remarkably contorted, as well as coherent into a mass.

302. The union of the pistils is still more common than that of the stamens. It occurs in every degree, from the partial combination of the ovaries, as in Sullivantia (Fig. 600), and in Penthorum (Fig. 183), &c., to their complete union while the styles remain distinct, as in Hypericum (Fig. 443), to the partial union of the latter, as in the Mallow (Fig. 462), or to the perfect union of the styles also into a single body, as in Convolvulus (Fig. 793). In some cases, as in the Forget-me-not (Fig. 761), the styles are combined, while the ovaries are only partially so. In the Milk-weed, the stigmas are united, but the ovaries nearly distinct.

189 190



191

303. The cohesion of the different sets of floral organs with one another takes place in various degrees, and often greatly obscures their real origin, by presenting the appearance of one whorl or set of parts growing out of another; as the corolla out of the calyx, the stamens out of the corolla, or all these organs out of the pistil; while these

FIG. 189. Column of stamens, at once triadelphous and syngenesious, of the Gourd: the floral envelopes cut away. 190. A cross section of the united anthers, nearly the natural size. 192. A sinuous anther of the Melon.

several organs all really arise from the receptacle or axis in successive series, one within or above the other (290). In the numerous cases where the real origin, or *insertion*, of the floral organs is not obscured by these cohesions, but where they are in appearance as well as in theory inserted on the receptacle, the calyx, corolla, and stamens are said to be *hypogynous*, that is, inserted below the pistils; as in the Buttercup (Fig. 347), the Papaw (Fig. 362), and the Helianthemum (Fig. 430, 432). The floral organs in such cases are also said to be *free;* which is the term opposed to the adhesion of one organ to another, as that of *distinct* is to the cohesion of the parts of the same whorl or set of organs. Thus, the stamens are said to be *distinct*, when not united with each other, and to be *free* when they contract no adhesion to the petals, sepals, or pistils; and the same language is equally applied to all the floral organs. When the petals or stamens adhere to (in botanical language, are *inserted* into or upon) the calyx, they are said to be *perigynous* (as in the Buckthorn, Fig. 508); and the same term is often applied to the calyx when it coheres with the base of the ovary (as in Fig. 512, 600), &c. Very frequently the calyx invests and coheres with the whole surface of the ovary, so that all the parts of the flower seem to grow out of its summit; as in the Honeysuckle (Fig. 624), the Valerian (Fig. 649), the Vaccinium or Whortleberry (Fig. 669), &c. The older botanists called the flower, or calyx, in such cases, *superior*, or the ovary and fruit, *inferior;* and when no such combination occurs, the flower, or calyx, &c., was said to be *inferior;* or the ovary, *superior*. But these terms are nearly, and should be altogether, superseded by the equivalent and more appropriate expressions of *calyx adherent* in the one case, and *calyx free* in the other; or that of *ovary coherent with the calyx*, and *ovary free from the calyx*, which is the same

thing in other words. When all the surrounding parts are thus consolidated with the ovary, and seem to grow from its summit, the calyx, corolla, and stamens are sometimes termed *epigynous;* that is, growing on the ovary (as in Aralia, Fig. 616); just as *perigynous* denotes their insertion around the ovary, and *hypogynous*, beneath it.

304. The various parts of the flower, thus consolidated, may separate into their integral elements at the point where they become free from the ovary, as in Cornus (Fig. 620); or else remain variously combined; the calyx being frequently prolonged into a tube with which the petals and stamens cohere, as in the Gooseberry (Fig. 587), and in Œnothera, where the united sepals form a long and slender tube (Fig. 577), bearing the petals and stamens on its summit. In the Button-bush (Fig. 635), and in numerous cases, the stamens continue their adhesion to the corolla; while in the Orchis tribe (Fig. 1011), they are free from the corolla, but adherent to the pistil, or *gynandrous*.

305. A complete flower, as already remarked (292), comprises four whorls or sets of organs; namely, calyx, corolla, stamens, and pistils: when any of these are wanting, the flower is said to be *incomplete*. Deviations resulting from the non-production of one or more of the whorls are not uncommon, and may affect any of the floral organs. The calyx, however, is never wanting when the corolla is present, as is evident from the very definition of the two kinds of floral envelopes (286): its apparent suppression in such cases is usually owing to the entire cohesion of the tube with the ovary, and the reduction of the free portion, or limb, to an obscure ring or border, either slightly toothed or entire, as in the Grape (Fig. 515), Aralia (Fig. 616), and Fedia (Fig. 646). In Compositæ, the limb of the reduced calyx, when present, consists of scales, bristles, or a ring of slender hairs (Fig. 656–662), and re-

ceives the name of *pappus*. The petals, however, are frequently absent; when the flower is said to be *apetalous*, or, if the calyx be present, *monochlamydeous*, that is, with a single floral envelope; as in Asarum (Fig. 843), Sassafras (Fig. 875), Dirca (Fig. 886), &c. But sometimes both the calyx and the corolla are entirely wanting, as in Saururus (Fig. 899), and Callitriche (Fig. 907), when the flowers, being destitute of floral envelopes, are termed *achlamydeous*. The essential organs (291) are nevertheless present in these cases, so that the flower is *perfect*, although *incomplete*.

306. A still further reduction, however, occurs in many plants; where even these essential organs are not both present in the same flower, but the stamens disappear in some flowers, and the pistils in others; when they are said to be *diclinous*, *unisexual*, or *separated;* and the flower which bears stamens only is termed *sterile*, or *staminate*, and that provided with pistils only, *fertile*, or *pistillate*. This separation of the essential organs is very frequently met with where the floral envelopes are present, as in Menispermum (Fig. 366, 368), and Prickly Ash (Fig. 484, 485); but when these are absent, it presents instances of the greatest possible reduction of which the flower is susceptible.* An example of the kind is furnished by Ceratiola, the sterile flowers of which consist merely of a couple of stamens

* Except, perhaps, in what are called *neutral flowers*, such as those which occupy the margin of the cymes of several Viburnums and Hydrangeas, or even the whole cluster in some monstrous states, as in the Snowball or Guelder Rose of the gardens (Viburnum Opulus), and the cultivated Hydrangea, which consist of floral envelopes only, with sometimes mere rudiments of stamens or pistils. Of the same kind are the *neutral florets* of Compositæ, such as the marginal flowers, or *rays*, of the Sunflower.

situated in the axil of a bract (Fig. 921); and the fertile, of a pistil surrounded by similar bracts (Fig. 923). In the Willow (Fig. 944 – 948), which presents a more familiar illustration, the sterile flowers likewise consist of two or three stamens in the axil of bracts, which form an ament (266); and the fertile, of solitary pistils also subtended by bracts, and disposed likewise in aments. The flowers of the Birch are very similar, except that three pistils, the sole representatives of as many flowers, are found under each bract of the fertile ament (Fig. 734 – 737). Separated or diclinous flowers are termed *monœcious* when the staminate and pistillate are both produced by the same individual plant; as in the Indian Corn, or Maize, the Birch, the Oak (Fig. 927), Beech, Hazel, the Hickory, &c.: and they are called *diœcious* when borne by different individuals; as in the Willow and Poplar, Sassafras (Fig. 874, 875), the Hemp, Hop, &c. In many cases, while some of the flowers are staminate only, a portion are perfect, the different kinds occurring either on the same or different individuals; as in most Palms, in many species of Maple, in Veratrum, &c.: plants with such flowers are said to be *polygamous*.

307. The suppression of an entire whorl of stamens is inferred to take place, from theoretical considerations, in those remarkable cases where the stamens equal the petals in number, but are situated opposite them, and so interfering with the regular alteration which is the usual plan. This occurs in the Vine (Fig. 515), the Buckthorn (Rhamnus, Fig. 508), the Primrose (Fig. 693), and uniformly in the natural families to which these respectively belong; and is explained by supposing that the first whorl of stamens (those which regularly alternate with the petals) have not been developed, (which is all that is meant by the term *suppression*,) and that those which do appear belong to a second whorl.

308. The symmetry of the flower is more frequently and seriously disturbed by the suppression of a part of the members of one or more whorls of the floral organs, than from any other cause. Thus, the pistils, which present their typical number in Sedum, and all Crassulaceous plants (Fig. 176, 178, 183), are reduced to two, or rarely three, in the allied Saxifragaceous family (as in Sullivantia, Fig. 600), while the other floral whorls are in fives. So, in Aralia (the Wild Sarsaparilla and Spikenard), the flowers are pentamerous (298, note) throughout, although the ovaries of the five pistils are united into one (Fig. 616); but in the Ginseng (Panax quinquefolium), the latter are reduced to two, as is also the case in all Umbelliferous plants (Fig. 606–611). The Mullein (Verbascum) is almost the only plant of the order Scrophulariaceæ which has as many perfect stamens as there are petals in the composition of its corolla, and sepals in its calyx. Sometimes the five stamens are all present, indeed; but one of them is either changed into a bearded sterile filament, as in Pentstemon and Chelone (Fig. 736); or reduced to a mere rudiment, as in some Snapdragons; or with the filament adherent to the corolla, and bearing a scale-like body in place of the anther, as in Scrophularia. The four remaining perfect stamens, in these cases, and nearly throughout the order, are unequally developed; two of them being longer than the remaining pair; as in Chelone, above cited, and Gerardia (Fig. 726); and the same thing is observed in most plants of the related orders Labiatæ, Orobanchaceæ (Fig. 721), and Verbenaceæ (Fig. 736). In such cases the stamens are said to be *didynamous*. Not unfrequently, a further suppression takes place, and two of these stamens either entirely disappear; as in the Sage, Monarda (Fig. 756), Lycopus Virginicus, &c., among Labiatæ; and Gratiola Virginica, &c., among the Scrophulariaceæ; or else are reduced to mere sterile

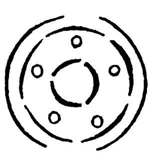
filaments, such as those which may commonly be observed in Gratiola aurea (Fig. 732), and which occur in the Wild Pennyroyal (Hedeoma), and many other Labiate plants.

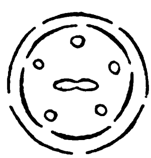
309. In most flowers with bilabiate (two-lipped) corollas, as in the order Labiatæ, which derives its name from this circumstance, and other plants with the didynamous or reduced stamens above described, the irregularity of form does not arise from the suppression of some of the petals, as might at first sight be supposed, but from their unequal union: the upper lip being formed by the more extensive cohesion of the two upper petals with each other than with the lateral ones; which in like manner unite with the lower or anterior petal to form the lower lip (Fig. 743, 735). But, in some such cases, the two upper petals do not cohere with each other as far as they do with the lateral ones, and, being smaller in size, the corolla has the appearance of wanting the upper lip, and shows a deep cleft in its place; as in Teucrium Canadense (Fig. 751). The flowers of Lobelia (Fig. 655) exhibit a striking instance of a similar kind; the two upper petals being united with the lateral (which are still further combined with the lower, to form the lower lip), but wholly unconnected with each other; so that the corolla appears to be split down to the base on the upper side. The ligulate or strap-shaped corollas of Compositæ (Fig. 654, 662) are evidently formed in the same way, as if by the splitting down of a tubular corolla (like those of Fig. 656, 659) on one side. In the bilabiate corolla of most Honeysuckles (as in Fig. 624), the upper lip consists of four united petals; the lower of only one.

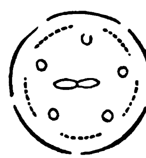
310. A single natural order (the Cruciferæ, to which the Cabbage, Mustard, and Radish belong), with regular tetramerous (298, note) or quaternary floral envelopes, is remarkable for its unsymmetrical stamens, which are six in number; four of them equal in length, while two are shorter

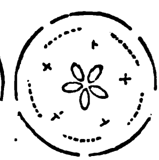
and exterior (Fig. 410); so that here we have one complete set of stamens, and half of another. The stamens in such cases are said to be *tetradynamous.*

311. The common Claytonia, or Spring Beauty (Fig. 452), the ornament of our vernal woods, may serve as a specimen of a complete flower rendered unsymmetrical by the suppression of a few parts out of two of the sets. The petals and the stamens are in fives, and therefore symmetrical, while three parts are lost out of the calyx, and two from the pistillate whorl, in which there is also a suppression of a different kind, hereafter to be noticed. The position of the stamens is also anomalous, being placed before the petals, instead of the intervals between them. Compare the annexed ground-plan of that flower (Fig. 192), with the pattern plan, Fig. 177. The Horse-Chestnut and Buckeye (Fig.


1 9


193


194


195

501 – 503) are somewhat similarly unsymmetrical, and, besides, the petals are irregular in shape. In Sullivantia (Fig. 600), and in the Dodder (Fig. 800 – 803), all is symmetrical and complete, except that the (united) pistils are

FIG. 192. Ground-plan of the Flower of Claytonia (Fig. 452); the outer lines representing the calyx of two sepals; the next set the corolla of five petals; next are the five stamens *before the petals;* and next the ovary composed of three parts.

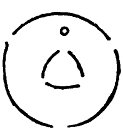
FIG. 193. Ground-plan of the Flower of Sullivantia (Fig. 600), or of the Dodder (Fig. 800); the united pistils reduced to two.

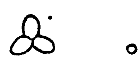
FIG. 194. Ground-plan of a flower of the Elm (Fig. 889); the five dotted lines indicating the proper position of the suppressed petals.

FIG. 195. Ground plan of a pistillate flower of Prickly Ash (Fig. 485); the series of dotted lines indicating the place which the petals, and the five crosses that which the stamens, should occupy, if present.

reduced to two, as is seen in the appended diagram (Fig. 193).

312. A series of such examples will illustrate those graver suppressions which render the flower incomplete, and finally reduce it to a minimum. Take firstly the Elm (Fig. 889), where the petals (the proper place of which is shown by the dotted lines in the diagram, Fig. 194) entirely disappear, and the pistils are reduced to two, both of which are abortive in a part of the flowers, and one always disappears in the fertile flowers during the formation of the fruit (Fig. 890, 891). The occurrence of innumerable cases of this kind justifies the use of the term *suppression*, in the case of parts which, though requisite in the ideal plan, are left out in the execution. Our Prickly Ash (Zanthoxylum, Fig. 484, 485) not only wants the petals altogether (which, however appear in the species of the Southern States), but the stamens also






196 197 a 198 b a 199 b

disappear in all the flowers of one tree, while the pistils are all abortive in those of another individual. Fig. 195 is a ground-plan of one of its fertile flowers; the dotted portions representing the parts that are suppressed. In the Blite (Fig. 850–857), where the plan is ternary, the petals and two of the stamens are entirely wanting; as the an-

FIG. 196. Diagram of the reduced flower of Blitum (Fig. 850).

FIG. 197. Diagram of a perfect flower of Callitriche (Fig. 908), which has no floral envelopes, a single stamen, and a four-celled pistil.

FIG. 198. Diagram of the monœcious flowers of Euphorbia: *a*, the pistillate flower, reduced to a mere three-celled pistil (Fig 916); and *b*, one of the staminate flowers (Fig. 915) reduced to a single stamen.

FIG. 199. Diagram of the diœcious flowers of the Willow (Fig. 945, 948): *a*, one of the pistillate flowers reduced to a solitary pistil; *b*, a staminate flower reduced to a pair of stamens.

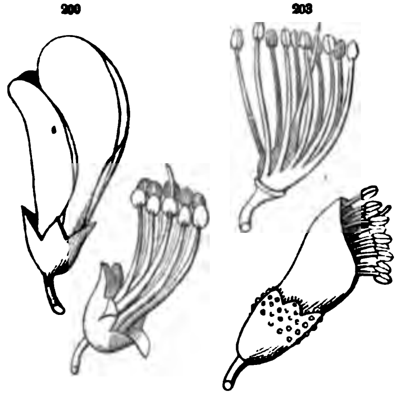
nexed diagram (Fig. 196) shows. In the Callitriche (Fig. 907 – 912), where the plan is quaternary, the calyx and the corolla wholly disappear, as well as all the stamens but one (Fig. 197); and even this stamen is wanting in some of the flowers on the same stem (Fig. 909), while other flowers consist of a single stamen only. This brings us to a case like that of Euphorbia (Fig. 913 – 918, illustrated by the diagram, Fig. 198), the greatly disguised structure of which is explained in the appended note.* Nearly the furthest possible reduction, perhaps, is seen in the Willow, where the staminate and pistillate flowers are distributed to different individual trees (Fig. 944, 947), the first reduced usually to a pair of stamens (Fig. 945), and the second to a single pistil (Fig. 948). Their plan is represented in the diagram, Fig. 199.

---

* What appears to be a single flower in Euphorbia is an extraordinary cluster. A single pedicellate, pistillate flower, consisting merely of three united pistils, with no floral envelopes (Fig. 914), is surrounded by a large number of staminate flowers (Fig. 915) reduced to a single stamen (*c*), and supported by a peduncle (*b*), which arises from the axil of a bract (*a*); and all inclosed in an involucre (seen in a vertical section at Fig. 912), closely resembling a calyx or corolla; so that the whole cluster has the appearance of a single flower, for which it was formerly mistaken. This curious structure, having once been explained by the greatest of botanists, (Robert Brown,) it is easy to find abundant evidence in its support among the allies of Euphorbia. Some plants of the family have one or more additional stamens arising from the joint at the apex of the pedicel (Fig. 915); in other cases these stamens are surrounded by a calyx, or sometimes by a whorl of petals also; and, finally, the flower is completed in some genera of the order by the appearance of the pistils in the centre. It is by comparing in this manner one flower with others of the same family, that the real structure is detected in all these anomalous cases.

313. The Pea tribe affords a familiar illustration of irregular flowers, arising from the unequal size and dissimilar form of the floral envelopes; especially of the corolla, which, from a fancied resemblance to a butterfly in the flower of the Pea, &c., has been called *papilionaceous*. The petals of such a corolla are distinguished by separate names; the upper one, which is usually most conspicuous, being termed the ***vexillum***, ***standard***, or ***banner*** (Ex. Lathyrus, Fig. 531, *a*); the two lateral (*b*) are called ***wings*** (*alæ*), and the two lower (*c*), which are usually somewhat united along their anterior edges, and more or less boat-shaped (Fig. 532), together form the ***keel*** (*carina*). The papilionaceous corolla exhibits a strong tendency to suppression in Erythrina, where the wings and keel are very small: in Amorpha (Fig. 202) these wholly disappear, leaving only a single petal (the vexillum) to represent the corolla. It manifests a slight tendency to become regular in Baptisia (Fig. 200), still more in Sophora, and especially in Cercis (the Red-bud or Judas-tree), and most of all in Cassia; where the five petals are separate, spreading, and almost similar in size and form. The irregular flower of Polygala (Fig. 521 – 524) is somewhat

200 203



201 202

FIG. 200. Papilionaceous flower of Baptisia. **201.** The same with the petals removed, showing the ten distinct stamens.

FIG. 202. Flower of Amorpha. **203.** The same with the solitary petal removed, showing the slightly monadelphous stamens.

similar, but is further complicated by the cohesion of the stamens with the petals.

314. In the Aquilegia, or Columbine (Fig. 351), the five petals (Fig. 352) are similar in size and appearance, but unusual in form, being prolonged at the base into a hollow spur. In the Delphinium, or Larkspur, the base of one of the five sepals is produced into a spur (Fig. 356); and the petals are unsymmetrical as well as irregular; being only four in number (Fig. 357); two of them prolonged in the form of spurs, which are received into the spur of the calyx; and the other pair very different in shape, and raised on slender stalks or claws. In the nearly related Aconite, or Monks-hood, the sepals are still more irregular, and two of the petals of a singular form, not unlike some stamens in appearance, while the remaining three are either minute or converted into stamens.

315. Among the unusual states of the receptacle, which more or less obscure the true arrangement of some of the floral organs, one of the most singular is that of the Nelumbo, where it is dilated into a large top-shaped body, nearly inclosing the pistils in separate cavities (Fig. 204). In the Rose, the receptacle forms a lining to the urn-shaped tube of the calyx, and bears the numerous pistils on its concave surface (Fig. 563), and the plan of the Calycanthus (Fig. 206, *a*) is much the same. In the Geranium, and many allied plants, the receptacle, which elevates the ovaries more or less, is prolonged above them, and coheres with their styles (Fig. 479). Sometimes the nature of the receptacle is rendered manifest by the appearance of one or more of

204

FIG. 204. The enlarged receptacle of Nelumbo.

its internodes; as in the Pink and Silene (Fig. 450), where the internode between the calyx and the corolla is developed in the form of a stalk which elevates the petals with the stamens and pistils; in some Gentians (Fig. 818), &c., where the internode above the stamens appears in the form of a stalk (*stipe*) to the gynæcium, which consists of two united ovaries. In Gynandropsis two internodes are conspicuously developed, one between the petals and the stamens, the other between the latter and the gynæcium; so that the stamens appear to grow out of a long stalk which supports the ovary (Fig. 205). If the lowest internode of the receptacle were here developed, as in the Pink tribe, between the calyx and corolla, the several whorls which compose the flower would be separated, like so many sets of verticillate leaves.


205

316. Having already used the terms anterior and posterior, or lower and upper, as applied to the parts of the flower, it is necessary to explain the manner of their application. All lateral or axillary flowers (256) are situated between the stem and a leaf, or, which is the same thing, between a bract and the axis of inflorescence. That part of the flower which lies next the leaf or bract from whose axil it arises, is said to be *anterior*, or *inferior* (lower); and the diametrically opposite point, which looks towards the stem or axis, is termed *posterior*, or *superior* (upper). Thus, in labiate flowers, the two principal portions of the

FIG. 205. Flower of Gynandropsis; its component organs separated by an enlargement of the receptacle just above the calyx, and its remarkable elongation above the petals, &c.

corolla are distinguished into the upper and lower, or posterior and anterior lips. When the floral organs are in fours, one part will be upper or posterior, one lower or anterior, and the other two *lateral*, being placed right and left of the axis. When they are in whorls of five, if one sepal be superior or posterior (next the axis), there will be two inferior or anterior (next the bract), and two lateral; as in the orders Rosaceæ, Labiatæ, Scrophulariaceæ, &c. And, since the petals regularly alternate with the sepals, two of these will in such case be superior, two lateral, and the odd one inferior; which explains why the upper lip of the corolla in Labiatæ (Fig. 758), &c., should always consist of two, and the lower of three petals. If the stamens form only a single whorl, they will, in accordance with the same plan of alternation, have one of their number superior (and it is this which is uniformly suppressed when they are didynamous), two lateral, and two inferior. But when the old sepal is inferior, two others will be superior, as in the Pea tribe, or Leguminosæ; and consequently the odd petal (vexillum, 313) superior, and the two opposite (which form the keel) inferior.

§ 3. Of the Theoretical Nature of the Flower.

317. The flower may next be viewed under a more theoretical aspect. In the preceding chapter, we have recognized the close analogy of flower-buds to leaf-buds, and consequently of flowers to branches, and of the leaves of the flower to ordinary leaves. The plant continues for a considerable time to produce buds which develope into branches. At length it produces buds which expand into blossoms. Is there an entirely new system introduced when flowers appear? Are the blossoms formed upon such a different plan, that the general laws of vegetation, which have

sufficed for the interpretation of all the phenomena up to the inflorescence, are to afford no further clew? Or, on the contrary, now that peculiar results are to be attained, are the simple and plastic organs of vegetation — the stem and leaves — developed in new and modified forms for the accomplishment of these new ends? The latter, doubtless, is the correct view. The plant does not produce essentially new kinds of organs to fulfil the new conditions, but adopts and adapts the old. New laws of development are now introduced; but these operate subordinately to the primary laws of vegetation, instead of subverting them.

318. In vegetation, new organs are not created for every or any contingency; but the root, stem, and leaves are modified, as circumstances require, to subserve every needful purpose. Thus, the same organ which constitutes the stem of an herb, or the trunk of a tree, we recognize in the trailing vine, or twiner, spirally climbing other stems, in the straw of Wheat and other Grasses, in the columnar trunk of the Palm, in the flattened and jointed Opuntia, or Prickly-pear, and in the rounded, lump-like body of the Melon-Cactus. So, also, the branches harden into spines in the Thorn, or, by an opposite change, become flexible and attenuated tendrils in the Vine, and runners in the Strawberry; or, when developed under ground, they assume the aspect of creeping roots, and sometimes form thickened rootstocks, as in the Calamus, or tubers, as in the Potato. But the type is easily seen through these disguises. They are all mere modifications of the stem. The leaves, as we have already seen, appear under a still greater variety of forms, some of them as widely different from the common type of foliage as can be imagined; such, for example, as the thickened and obese leaves of the Mesembryanthemums; the intense scarlet or crimson floral leaves of the Euchroma, or Painted-Cup, the Poinsettia of our conservatories, and several Mexican

18*

Sages; the tendrils of the Pea tribe; the Pitchers (Fig. 144 – 146) of the Sarracenia, &c., and those of the Nepenthes, which are leaf, tendril, and pitcher, combined. The leaves also appear under very different aspects in the same individual plant, according to the purposes they are intended to subserve. The first pair of leaves, or cotyledons (45), as in the Bean and Almond, gorged with nutritive matter for the supply of the earliest wants of the embryo-plant, seem to be peculiar organs. But when they have discharged this special office in germination, by yielding to the young plant their store of nourishment with which they are laden, they throw off their disguise, and assume the color and appearance of ordinary foliage. As the stem elongates, the successive leaves vary in form or size, according to the varying vigor of vegetation. In our trees, we trace the last leaves of the season into bud-scales; and in the returning spring we often observe the innermost scales of the expanding leaf-buds to resume, the first perhaps imperfectly, but the ensuing ones successfully, the appearance and the ordinary office of leaves (Fig. 53 – 56).

319. Analogy would therefore suggest, that in the final act of vegetable development, in flowering, the leaves, no longer developing as mere foliage, are now wrought into new forms, to subserve peculiar purposes. In the chapter on Inflorescence, we have already shown that the arrangement and situation of flowers upon the stem conforms to this idea. In this respect, flowers are absolutely like branches. The aspect of the floral envelopes favors the same view. We discern the typical element, the leaf, in the calyx; and again, more delicate and refined, in the petals. In numberless instances, we observe a regular transition from ordinary leaves into sepals, and from sepals into petals. And, while the petals are occasionally green and herbaceous, the undoubted foliage sometimes assumes a

delicate texture and the brightest hues. Familiar cases of the latter kind have just been alluded to (318). The gradations of sepals into petals, or into leaves, are exemplified in the Magnolia, the Illicium, or Star-Anise, of the Southern States; and especially in the Calycanthus, or Carolina All-spice (Fig. 206), which presents several series of floral envelopes, all nearly alike in color, texture, and shape; but how many of the innermost are to be called petals, and how the remainder are to be divided between sepals and bracts, is entirely a matter of arbitrary opinion. In fact, the only real difference between the calyx and corolla is, that the former is the outer, and the latter an inner series of floral envelopes (286). But there are further considerations which confirm this view, and, indeed, demonstrate that the flower is, as it were, a peculiar sort of branch. Some of these we will briefly mention, under separate heads.

206

320. (1st.) *The successive and actual transition of sepals into petals, and of petals into stamens;* so that, if it be admitted that the sepals are leaves (and botanists are unable to establish any absolute distinction between them and bracts, or bractlets (272), and between these and ordinary leaves), it must follow that stamens, different as they generally are in appearance, also have the same essential nature. Although there is usually but little resemblance between them, yet in many cases the transition of sepals into petals is not

FIG. 206. Flowers of Calycanthus: *a*, vertical section of a flower.

more evident than that of the latter into stamens. This is especially exemplified in the common White Water-Lily (Fig. 393–395), in which the petals occupy several whorls, and, while the exterior are nearly undistinguishable from the calyx, the inner are reduced into organs which are neither well-formed petals nor stamens, but intermediate between the two. They are merely petals of a smaller size, with their summit contracted and transformed into an imperfect anther, containing a few grains of pollen: those of the series next within are more reduced in size, and bear perfect anthers at the apex; and a still further reduction of the lower part of the petal completes the transition into stamens of ordinary appearance. The transformation of stamens into pistils is occasionally seen in certain garden Poppies, and in monstrous states of the Willow, the House-Leek, &c. These are monsters, it is true,— literally *shows*,— but not the less instructive or convincing on that account.

321. This regular transformation takes an upward course, from leaves into sepals, from sepals into petals, and from the latter into stamens, or even into pistils. We trace the typical leaf forward into the floral envelopes, and thence into the essential organs of the blossom. This is the *regular metamorphosis*, if we may use that somewhat ambiguous term. Now if these organs be, as it were, leaves developed in peculiar states under the controlling agency of a power which has overcome or modified the ordinary forces of vegetation, they must always have a tendency to develope in their primitive form, when the causes that govern the production of blossoms are interfered with. They may then reverse the spell, and revert into some organ below them in the series, as from stamens into petals, or pass at once into the state of ordinary leaves. Such cases occur in a variety of ways, as, for example,

322. (2d.) *In the actual reconversion of the pistils into a*

leaf; which takes place in some cultivated plants, particularly in a monstrous state of the Cherry; where a small green leaf, of ordinary appearance, or else half-transformed into an ovary (as in Fig. 219, 220), is developed instead of the pistil: *or of stamens into petals;* which is also seen in the Double Cherry, and is of familiar occurrence in double or semi-double flowers of the garden; such as Tulips, Carnations, Camellias, Roses, and others. In these the stamens disappear as the supernumerary petals increase in number; and the various bodies that may be often observed, intermediate between perfect stamens (if any remain) and the outer row of petals, — from imperfect petals with a small lamina tapering into a slender stalk, to those which bear a small distorted lamina on one side and a half-formed anther on the other, — plainly reveal the nature of the transformation that has taken place. The garden Columbine often affords beautiful illustrations of this kind. There is a monstrous state of the Strawberry, well known in Europe, in which all the floral organs revert into green sepals, or imperfect leaves. The subjoined illustration (Fig. 207) from Turpin exhibits a

207

FIG. 207. A flower of the common White Clover reverting to a leafy branch.

similar *retrograde metamorphosis* in the White Clover, in which the calyx, pistil, &c., are still recognizable.

323. (3d.) Analogous cases of retrograde metamorphosis are seen in *the production of a leafy branch from the centre of a flower, or of one flower out of the centre of another* (as rose-buds out of roses); which shows that the

207[2]

receptacle (290), or axis of the flower, may, under the influence of powerful forces of vegetation, resume the ordinary mode of growth of the branch. This *reversion* more commonly takes place after the formation of the floral envelopes and stamens, but before the pistils appear; as in Fig. 207[2]. The appearance of a leafy branch from the summit of a Pear (as in Fig. 208), is similarly explained. In very wet and warm springs, some of the flower-buds of the Pear and Apple are occasionally forced into active vegetative growth, so as to break up the whorls of the flower, and change it into an ordinary leafy branch.

324. (4th.) Another class of these illustrations is found in *the occasional production of buds (either as branches or flowers) in the axils of the floral envelopes, or even of the stamens.* In such cases the parts of the flower exhibit one of the distinguishing characters of leaves, that of developing buds in their axils. An instance of the kind was observed by Kunth in a flower of the False Bitter-Sweet (Celastrus scandens), which bore a perfect flower in the axil of each of the petals (Fig. 209). Of this sort are some

FIG. 207[2]. Retrograde metamorphosis of a flower of the Fraxinella of the gardens: from Lindley's Theory of Horticulture.

of the cases in which two or more fruits grow out of another fruit, as often happens in apples and pears. This kind of monstrosity is frequent in the Rose. We have recently met with a Clarkia elegans, which bore an imperfect blossom in the axil of each petal.

208

325. The irresistible conclusion from all such evidence is, that the flower is one of the forms, — the ultimate form, — under which branches appear; that the leaves of the stem, the leaves or petals of the flower, and even the stamens and pistils, are all forms of a common type, only differing in their special development. And it may be added, that in the earliest state in which these parts are discernible with a powerful microscope, they all appear alike. That which, under the ordinary laws of vegetation, would have developed as a leafy branch, does, from peculiar causes, finally develope as a flower; its several organs appearing under forms, some of them slightly and others extremely different in aspect and in office from the foliage. But they all have a common nature and a common origin.

326. Now, as we have no general name to comprehend all those organs which, as leaves, bud-scales, bracts, sepals, petals, stamens, &c., successively spring from the ascending axis, or stem, having ascertained their essential identity, we naturally, and indeed necessarily, take some one of them as the *type*, and view the others as modifications, or metamorphoses of it. The leaf is the form which earliest appears, and is the most general of all the organs of the

FIG. 208. A monstrous pear, bearing a leafy branch.

vegetable; it is the form which is indispensable to vegetation, in which it plays, as we have seen, the most important part; it is the form into which all the floral organs may

209

sometimes be traced back by numerous gradations, and to which they are liable to revert when flowering is disturbed and the proper vegetative forces again prevail. Hence the leaf is properly assumed as the type, to which all the others are to be referred. When, therefore, in accordance with these theoretic views, the floral organs are termed *modified* or *metamorphosed leaves*, it is not to be supposed that a petal has ever actually been a green leaf, and has subsequently assumed a more delicate texture and hue, or that stamens and pistils have previously existed in the state of foliage; but only that what is fundamentally one and the same organ developes, in the progressive evolution of the plant, under any of these various forms. When the individual organ is once developed, its destiny is fixed.

327. The theory of vegetable morphology may be expressed in other, and more hypothetical or transcendental forms. We have preferred to enunciate it in the simplest and most general terms. But, under whatever particular formula expressed, its adoption has not only greatly simplified, but has thrown a flood of light over the whole of Structural Botany; and has consequently placed the whole logic of Systematic Botany upon a new and truly philosophical basis. Our restricted limits will not allow us to trace its historical development. Suffice it to say, that the idea of the essential identity of the floral organs and the leaves was distinct-

FIG. 209. A flower of Celastrus scandens, producing other flowers in the axils of the petals: from Turpin.

ly propounded by Linnæus,* about the middle of the last century. It was newly taught by Caspar Frederic Wolff about twenty years later, and again, after the lapse of nearly twenty years more, by the celebrated Goethe, who was entirely ignorant, as apparently were his scientific contemporaries, of what Linnæus and Wolff had written on the subject. His curious and really scientific treatise was as completely forgotten or overlooked as the significant hints of Linnæus had been. In advance of the science of the day, and more or less incumbered with hypothetical speculations, none of these writings appear to have exerted any influence over the progress of the science, until it had reached a point, early in the present century, when the nearly simultaneous generalizations of several botanists, following different clews, were leading inevitably to the same conclusions. Ignorant of the writings of Goethe and Wolff, De Candolle was the first to develope, from an independent and original point of view, the idea of symmetry in the flower; that the plan, or type, of the blossom is regular and symmetrical, but that this symmetry is more or less modified or disguised by secondary influences, giving rise to various deviations, such as those of which we have already treated (§ 2). The cause, however, of the regularity and symmetry, or the true explanation of the prevailing arrangement of its parts, upon which the symmetry depends, has very recently been made apparent. It necessarily results from the laws which govern the spiral arrangement and relative position of leaves upon the stem (183 – 186), and which, as our theoretic views would lead

---

* "Principium *florum* et *foliorum* idem est. Principium gemmarum et foliorum idem est. Gemma constat foliorum rudimentis. Perianthium sit ex connatis foliorum rudimentis," etc. *Philosophia Botanica*, p. 301.

us to anticipate, are carried out to the flower, and to all parts that are modifications of leaves. Their detailed application to the floral structure, however, involves considerations somewhat too recondite for so elementary a treatise as the present.

§ 4. Of the Floral Envelopes; their Æstivation, &c.

328. The relative position of the different parts of the flower is readiest made out in the flower-bud, just before its expansion. The manner in which the parts of the blossom, especially of the calyx and corolla, stand in relation to and envelope each other, was fancifully termed by Linnæus their Æstivation.* By some authors it is also called *præfloration*. Several varieties in this respect are distinguished by systematic botanists; but they may all be reduced to two principal plans; the *imbricated*, or *spiral*, and the *valvular*.

329. In the first of these, which is by far the most common, the sepals or petals evidently follow the same spiral arrangement as the leaves; the axis being merely shortened, so as to bring the calyx or corolla into an apparent circle. The pieces do not compose a simple circle, however, for the outermost, in the bud, cover the edges of the inner, or *break joints*, as the term *imbricated* denotes, like the shingles upon a roof. This is seen in the cross section, Fig. 213, of a calyx like the Rose, which is imbricated in the typical or *quincuncial* mode. The sepals are here five in number, two of them exterior, and two interior (and

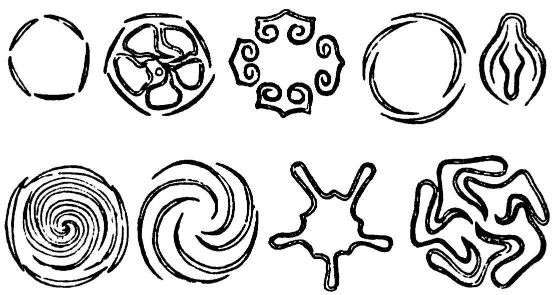
* Literally, their summer state; so called for no apparent reason, except that Linnæus had already applied the name of *Vernation* (the spring-state) to express the manner in which leaves are disposed in the leaf-bud.

consequently inserted a little higher up, 284, 290), and the remaining piece overlapping one of the inner by one margin, while the other margin is covered by the outermost sepal. By tracing a dotted line from the other edge of the outermost (which in the diagram is the upper) sepal, to the adjacent edge of the second, and thence to the third, fourth, and fifth, a regular spiral is described, just like that which the leaves describe on an ordinary leafy branch in the case of the most general spiral arrangement (183). The only difference is that here, by the suppression or extreme abbreviation of the internodes, the spiral is depressed nearly into a horizontal plane. This regular spiral mode passes by gradations into various subordinate forms; such as the *vexillary*, peculiar to the papilionaceous corolla (313), where the vexillum is wrapped around the other petals, as in Fig. 214; and also the *contorted*, *twisted*, or *convolute*, where each piece is as it were slightly twisted on its axis so as to have one margin interior and the other exterior; consequently all are more or less oblique, and successively overlap each other; as the petals of the Wall-flower (Fig. 215), the lobes of the corolla of Phlox (Fig. 216, and 775), the petals of Hypericum (Fig. 442), Flax (Fig. 472), &c. In the *plicate*, or *plaited*, form, a monopetalous corolla is thrown into plaits or folds, as in the Stramonium, and the Campanula (Fig. 217), and in the *supervolute*, these plaits are twisted, as in the Convolvulus (Fig. 218, and 792.)

330. In the *valvular* mode of æstivation, the leaves of the calyx or corolla are disposed in a true circle, and their edges are consequently brought into contact in the bud without overlapping. The calyx is simply *valvate* (Fig. 210) in the Mallow tribe, and the Linden (Fig. 468); so are the petals of the Vine (Fig. 515). The induplicate mode (Fig. 212) is a modification of the valvate, where the margins are bent or rolled inwards, as in the sepals of

Clematis; when rolled inwards until they meet, the æstivation is involute, as in the petals of Lysimachia (Fig. 211); when the edges are turned outwards instead of inwards, the æstivation is *reduplicate*, as in the blossom of the Potato.

210 211 212 213 214



215 216 217 218

331. The æstivation of the two sets of floral envelopes is frequently very different; and the change is quite constant and characteristic of certain families of plants. Thus, in the Mallow tribe, the æstivation of the calyx is valvate, of the corolla contorted. In the Convolvulus and the Wallflower (Fig. 215), the calyx is imbricated, the corolla contorted. In the Lysimachia, the calyx is valvate, and the corolla involute (Fig. 211). In the Cistus tribe, the calyx and corolla are both twisted, but in opposite directions (Fig. 430). Sometimes terms expressive of the mode of æstivation are applied to the petals individually. Thus, the petals of the Poppy, and in a lesser degree those of the Helianthemum (Fig. 430), are *corrugate*, or *crumpled*, in æstivation.

332. The course we have already pursued has naturally

FIG. 210–218. Different kinds of æstivation, illustrated by transverse sections of the unexpanded floral envelopes.

led us to notice the principal modifications of the calyx and corolla, as well as the terms employed to designate them; which need not be here repeated.

333. The number of the *sepals* and *petals* (285) is distinguished by Greek numerals prefixed to these names; such as *disepalous*, or *dipetalous*, when the sepals or petals are only two; *trisepalous*, or *tripetalous*, when three in number; *tetrasepalous*, or *tetrapetalous*, when four; *quinquesepalous*, or *quinquepetalous*, when five; *hexasepalous*, or *hexapetalous*, when six; and so on. But the terms *polysepalous* and *polypetalous*, which literally mean that the calyx and corolla consist of many sepals and petals, are in general use to express the absence of cohesion, whatever be their number. Thus, the term *Calyx polysepalous* (or sometimes *polyphyllous*, many-leaved) is equivalent to the more appropriate expression, *Sepals distinct;* and that of *Corolla polypetalous* to *Petals distinct.* Hence, likewise, the calyx is said to be *monosepalous*, or *monophyllous* (literally of one sepal or leaf), when the sepals are united; and the corolla *monopetalous* (of one petal) when the petals are united, as already explained; it being generally thought unnecessary to supersede terms so long in use, although inappropriate, by the correct expressions of *Calyx gamosepalous*, and *Corolla gamopetalous* (300).

334. Frequently the petals, and sometimes the sepals, taper into a stalk or narrow base, analogous to the petiole of a leaf, which is called the *claw* (*unguis*); and hence the petal is said to be *unguiculate* (as in Cruciferous plants, the Pink, and Gynandropsis, Fig. 205, &c.); the expanded portion, like that of the leaf, being distinguished by the name of the *lamina*, or *limb*.

335. Some kinds of polypetalous flowers receive particular names, from the form or arrangement of their floral envelopes. Among the *regular* forms (295) we may men-

tion the *rosaceous* flower (like that of the Rose, Apple, Fig. 568, &c.), where the spreading petals have no claws, or very short ones; the *liliaceous*, of which the Lily is the type, where the claws or base of the petals or sepals are erect, and gradually spread towards their summits (Ex. Erythronium, Fig. 1025); the *caryophyllaceous*, as in the Pink and Silene (Fig. 449), where the five petals have long and narrow claws, which are inclosed in the tube of the calyx; and the *cruciate*, or *cruciform*, which gives name to the order Cruciferæ, where four unguiculate petals are disposed in the form of a cross: this arrangement of the corolla is accompanied by tetradynamous stamens (310). Among the *irregular* polypetalous flowers, which are greatly varied in different families, the *papilionaceous* or *butterfly-shaped* corolla has already been described (313).

335[a]. When the petals are confluent into a monopetalous or gamopetalous corolla, or the sepals into a monosepalous or gamosepalous calyx, the united portions constitute the *tube;* the orifice of which is called the *throat;* and their free summits are termed *divisions*, *lobes*, *segments*, *teeth*, &c., in accordance with the convenient, but very unphilosophical, mode of nomenclature, which we have sufficiently explained (155, 300). When there is a manifest distinction between the tubular portion and the spreading summit, the latter is called the *limb*, or *border;* which is in like manner said to be *divided*, *parted*, *lobed*, *cleft*, *toothed*, &c., according to the extent of the union of its elements.

336. Several forms of the monopetalous corolla, or monosepalous calyx, have been distinguished by particular names. These are likewise divided into the *regular* (295), where their parts are equal in size, or equally united; and the *irregular*, where their size or degree of union is unequal. Among the former are the *campanulate*, or *bell-shaped*, as in the corolla of Campanula (Fig. 653) and Apocynum

androsæmifolium (Fig. 822), which enlarges gradually and regularly from the base to the summit; the *infundibuliform*, or *funnel-shaped*, where the tube enlarges very gradually below, but expands widely at the summit, as the corolla of Convolvulus (Fig. 792), and the Tobacco (Fig. 806); *tubular*, where the form is cylindrical throughout; *hypocrateriform*, where the limb spreads at right angles with the summit of the more or less elongated tube, as in the corolla of Primula and of Phlox (Fig. 775); and *rotate*, when a hypocrateriform corolla has a very short tube, as in Myosotis (Fig. 760), and Solanum Dulcamara (Fig. 802). The principal irregular form, which has received a separate appellation, is the *labiate;* which is produced by the unequal extent of the union of the sepals or petals, so as to form two portions or *lips*, as already explained (309). This variety is almost universally exhibited by the corolla of Labiatæ, and very frequently by the calyx also, as in the Sage (Fig. 758): it likewise occurs in the corolla of most Honeysuckles (Fig. 624), and in the calyx of many Leguminous plants. When the upper lip is arched, as in the corolla of Lamium (Fig. 744), it is sometimes called the *galea*, or *helmet*. When the two lips are separated and the throat (335) open, it is said to be *ringent*. But when the orifice is closed by the approximation of the two lips, or especially by an elevated portion or protuberance of the lower, called the *palate*, as in the Snapdragon (Fig. 733), the corolla is said to be *personate*, or *masked*.

337. The petals are sometimes furnished with appendages on their inner surface, such as the *crown* at the summit of the claws in Silene (Fig. 451), and the scales similarly situated on the gamopetalous corolla of Myosotis (Fig. 760) and Symphytum (Fig. 765); which perhaps represent an adherent row of abortive stamens or petals.

338. The bodies termed *nectaries* by the old botanists

are either petals of unusual form, such as the spurs of the Columbine (Fig. 351), or petals passing into stamens, such as the fringe of the Passion-flower and of Parnassia; or else abortive and transformed stamens, as in Canna. The so-called nectary of Orchidaceous plants (Fig. 1012) is merely one of the petals, which, being constantly of a different shape from the others, is termed the *labellum*, or *lip*.

§ 5. OF THE STAMENS.

339. The STAMENS, collectively forming the ANDRŒCIUM (287), have been already considered in respect to their component parts, their theoretical nature and symmetry, and their principal modifications as to relative number and disposition. Their absolute number in the flower, it may be remarked, is designated by Greek numerals prefixed to the word used for stamens, as employed by Linnæus in the names of his artificial classes. Thus a flower with one stamen is said to be *monandrous;* with two, *diandrous;* with three, *triandrous;* with four, *tetrandrous;* with five, *petandrous;* with six, *hexandrous;* with seven, *heptandrous;* with eight, *octandrous;* with nine, *enneandrous;* with ten, *decandrous;* with twelve, *dodecandrous;* and with a greater or indefinite number, *polyandrous.* The terms employed to designate their various modifications, already incidentally noticed, are likewise derived from the names of Linnæan artificial classes, with the exception of those which relate to their insertion; namely, as *hypogynous*, when inserted on the receptacle (as in Fig. 432), or, in other words, free from all adhesion to neighbouring organs; *perigynous*, when adherent to the tube of the calyx (as in Fig. 509); and *epigynous*, when adherent also to the ovary, and, as it were, raised upon its summit (as in Fig. 845). To these may be added the Linnæan term, *gynandrous*,

expressive of their further cohesion with the style, as in Orchidaceous plants.

340. As to mutual cohesion, they are *monadelphous* when united by their filaments into one body (as in Fig. 186); *diadelphous*, when thus combined in two sets (as in Fig. 185); *triadelphous*, when in three sets, &c.; *polyadelphous*, when in several sets, irrespective of the particular number; and *syngenesious*, when united by their anthers (Fig. 187, 188). As respects inequality of size, they are *didynamous*, when four stamens constitute two pairs of unequal length (308); and *tetradynamous*, when in a hexandrous flower two of the stamens are shorter than the others (310). Their complete suppression in some flowers gives rise to such terms as *monœcious*, *diœcious*, and *polygamous*, which have already been defined (306).

341. When the stamen is destitute of the filament, or stalk (Fig. 174, *a*), the anther (*b*) is said to be *sessile:* the filament being no more essential to the stamen than the claw is to the petal, or the petiole to the leaf. When the anther is imperfect, abortive, or wanting, the stamen is said to be *sterile*, *abortive*, or *rudimentary;* its real nature being known by its situation.

342. The filament, although usually slender and cylindrical, or slightly flattened, assumes a great variety of forms: it is sometimes dilated so as to be undistinguishable from the petals, except by its bearing an anther; as in the Nymphæa (White Water-Lily, Fig. 394), which clearly exhibits the gradual passage of petals into stamens (320).

343. The ANTHER (Fig. 174, *b*), which is the essential part of the stamen, is usually borne on the apex of the filament; and commonly consists of two *lobes*, or *cells* (*thecæ*), placed side by side, and attached to a prolongation of the filament called the *connectivum*, or *connective*. As the filament represents the petiole, so the connectivum repre-

sents the midrib of the transformed leaf; and the two lobes of the anther answer to the limb or blade of the leaf; the portion each side of the midrib forming an anther-lobe. The *pollen*, or powdery substance contained in the anther, originates from a peculiar transformation of the cellular tissue, or parenchyma of the leaf.

343[2]. The grains of pollen are formed, usually four together, in mother-cells, which are at length ruptured or absorbed, or their vestiges appear as minute shreds among the pollen-grains.

344. The parenchyma of the leaf, consisting of an upper and lower stratum (137), and again divided in the opposite direction by the midrib, is anatomically composed of four portions: the conversion of a part of the cellular tissue into pollen (which takes place long before the expansion of the flower) commences in the centre of each division: so that the anther is primarily and typically four-celled; each lobe being divided by a portion of untransformed tissue stretching from the connectivum to the opposite side, which corresponds to the margin of the leaf. This appearance is presented by a large number of full-grown anthers: but the partition usually disappears when the anther opens, or at an earlier period, when each lobe becomes single-celled (Fig. 639).

345. Each lobe of the anther is usually marked with a lateral line or furrow, running from top to bottom, which represents the margin of the metamorphosed leaf: this is the *suture*, or *line of dehiscence*, by which the anther commonly opens, when the flower has fully expanded, and allows the pollen to fall out (Fig. 363, 640). The opening of the anther at the proper period is facilitated by the peculiar structure of the lining of its walls; which consists of cellular tissue dissected into fibres (as is shown in Cobæa by Fig. 23); the contraction of which, as it becomes dry, tends

to open the cell, and force out the pollen. As this hygrometrical tissue contracts by dryness, the anther does not burst until the pollen is matured, nor except in dry weather, when alone it can fulfil its office.

346. The attachment of the anther to the filament presents three principal modes. 1st. When the base of the connectivum exactly corresponds with the apex of the filament and with the axis of the anther, the latter is termed *innate*, and rests firmly upon the summit of the filament. 2d. When the lobes of the anther are firmly adherent for their whole length to a prolongation of the filament, or broad connectivum (whichever it be called), so as to appear latéral, it is said to be *adnate;* as in the Magnolia (Fig. 359). When the filament or connective passes up on the outside of the anther, the latter faces the pistils, and is termed *introrse*, or *turned inwards*, as in the Water-Lily (Fig. 394); but when the filament adheres to their inner side, the anther looks away from the pistils and towards the petals or sepals, when it is said to be *extrorse*, or *turned outwards*, as in the Iris (Fig. 1020). 3d. When the anther is fixed by a point to the apex of the filament, on which it lightly swings, it is said to be *versatile;* as in all Grasses (Fig. 1046), the Lily, the Evening Primrose (Fig. 578), &c. In this case, as in the preceding, the anther is said to be *introrse*, when it is turned towards the pistil, which is the most common form; and *extrorse*, when it faces outwards.

347. Various deviations from the regular structure of the anther, as now described, frequently occur; some of which may be cursorily noticed. The opening of the anther, sometimes called its *dehiscence*, does not always take place in the manner above described (345); but occasionally the suture opens only at the top, in the form of a chink or pore; as in Pyrola (Fig. 677), and nearly all Ericaceous plants, in the Potato, &c. Sometimes the summit of the lobes is pro-

longed into a tube, which opens by a pore or chink at the apex; as in the Heath and Vaccinium (Fig. 671, 672). In the Barberry (Fig. 378), and other plants of the family, the Benzoin, &c., nearly the whole face of each anther-cell separates by a continuous line, forming a kind of door, which is attached at the top, and turns back, as if on a hinge: in this case the anthers are said to open by valves. In the Sassafras, and other plants of the Laurel tribe, each lobe of the anther opens by two such valves, like trap-doors, as in Fig. 876.

348. Sometimes the anthers are one-celled, by the suppression of one lobe, being reduced as it were to half-stamens, as in Gomphrena, and some other Amaranthaceous plants; but they more frequently become one-celled by the confluence of the two lobes, and the disappearance of the partition, as in Polygala (Fig. 525), where they open by a terminal pore. The kidney-shaped one-celled anthers of the Mallow tribe arise from the divergence of the base of the two lobes, and their perfect confluence at the apex; and the opening consequently takes place by a continuous sutural line passing round the margin (Fig. 461). A somewhat similar case occurs in Monarda (Fig. 757), where only one of the two lobes remains parallel with the filament or connectivum; while the other, describing a semicircle, is brought into the same vertical line, where it stands bottom upwards; and the two, cohering by their contiguous extremities, become confluent into a single cell, which opens by a continuous straight line from one end to the other. The anther of Teucrium (Fig. 764), differs from the last chiefly in the enlarged connectivum, on which the divaricate lobes rest; and the cells, at first distinct, are confluent into one after the anther opens. In the Thyme (Fig. 755), the anther-lobes are also greatly divergent, but are separated by the thickened connectivum, which in this family is often

larger than the cells. In the Sage (Fig. 750), the singular elongated connectivum sits astride the apex of the filament, and bears an anther-cell at each extremity; one of which (*a*) is polliniferous; and the other (*b*) imperfect or abortive.

349. The connectivum is frequently inconspicuous or almost wanting, and the lobes of the anther nearly unconnected; as in Euphorbia (Fig. 715). It is often produced beyond them into an appendage, as in Magnolia (Fig. 359), the Papaw (Fig. 363, where it forms a rounded top), and Asarum (Fig. 846). Of the same nature are the two dorsal awns in Fig. 672 – 674.

350. The POLLEN, contained in the anther, which appears to the naked eye like a mere powder, consists of grains of definite size and shape, which are uniform in the same plant, but often very different in different species or natural families. Although commonly spherical or oval, they are cylindrical in the Spiderwort (Tradescantia), nearly square in Colutea, many-sided in the Teasel; and triangular, with the angles dilated and rounded, in the Evening Primrose (Fig. 240). Their surface, although more frequently smooth and even, is banded or crested in many cases, reticulated in the Passion-flower, and studded with strong points in Convolvulus purpureus (Fig. 238), or short bristles in Hibiscus, the Mallow, and the Gourd. Their color is usually yellow.

351. The pollen-grains have two coats; the exterior of which, called the *extine*, is quite firm and often fleshy; to it the bands, points, or other markings belong. The inner, named the *intine*, is very thin, transparent, and highly extensible. It absorbs water rapidly, and, when exposed to its action, the grain swells and soon bursts, discharging its contents. These contents are a fluid, which appears slightly turbid under the higher powers of ordinary microscopes, but when submitted to a magnifying power of three hundred diameters, is found to contain a multitude of minute particles

(*fovillæ*) of spherical or oblong form, the larger of which are from the four-thousandth to the five-thousandth of an inch in length, and the smaller only one fourth or one sixth of this size. But they all exhibit a constant and exceedingly active molecular motion, the cause and object of which is unknown.

352. The grains of pollen are in most cases entirely distinct from each other; but in the Evening Primrose they are slightly connected by loose cellular threads (Fig. 579); they occasionally cohere, either in fours (343^2), as in many Ericaceous plants; or in masses of eight to sixteen grains, as in Mimosa and Acacia. But in two peculiar families, the Orchidaceæ and the Asclepiadaceæ, the grains are all coherent into one or more (called *pollinia*), which are sometimes apparently solid and wax-like, and sometimes manifestly cellular, as in Asclepias (Fig. 243), and in Orchis (Fig. 1014). The elastic substance to which the grains are all attached in the latter forms a kind of stalk, named the *caudicle*.

353. When the pollen-grains fall upon the stigma (357), the inner membrane is soon protruded through particular points, clefts, or valvular openings of the outer coat, in the form of an attenuated transparent tube (Fig. 237 – 240), filled with its fluid contents, which penetrates the naked and loose cellular tissue of the stigma, and buries itself in the style (Fig. 248). Its further course and office will be hereafter explained.

354. What is called the Disk consists of a ring, either entire or variously lobed, (or a row of fleshy bodies, often termed glands,) which sometimes intervenes between the stamens and the pistils, surrounding the base of the latter, when it is *hypogynous*, as in Convolvulus (Fig. 793), and the Vine (Fig. 516); sometimes it partly covers the ovary, and the stamens grow out of it; as in Euonymus, where

it is very conspicuous: frequently it adheres to and lines the tube of the calyx, carrying the stamens with it, as in Rosaceous plants, the Buckthorn (Fig. 508), &c., when it is *perigynous:* or when the calyx coheres with the ovary, it makes its appearance on the summit of the latter, when it is *epigynous*, as in Umbelliferæ and Aralia (Fig. 616). In this case, when confluent with the base of the style, it has been termed the *stylopodium*.

§ 6. Of the Pistils.

355. The Pistils (288) occupy the centre of the flower, and terminate the axis of growth. Their number is designated by Greek numerals, prefixed to the name applied to the pistil from the same language. Thus, a flower with a single pistil is said to be *monogynous;* with two, *digynous;* with three, *trigynous;* with four, *tetragynous;* with five, *pentagynous;* with six, *hexagynous;* with seven, *heptagynous*, and so on; and when numerous or indefinite, they are termed *polygynous*.

356. It is comparatively seldom that the pistils are actually equal to the petals or sepals (285) in number; they are sometimes more numerous, and arranged in several rows upon the enlarged or prolonged receptacle, as in the Strawberry (Fig. 557), and perhaps more frequently they are reduced to less than the typical number, or to a single one. Yet often what appears to be a single pistil is not so in reality, but a compound organ, formed by the union of two, three, or a greater number of simple pistils; as is shown in Fig. 221–227.

357. A pistil, as already described (289) is composed of three parts; the Ovary, or seed-bearing portion; the Style, or tapering portion, into which the apex of the ovary is prolonged; and the Stigma, usually situated at the summit

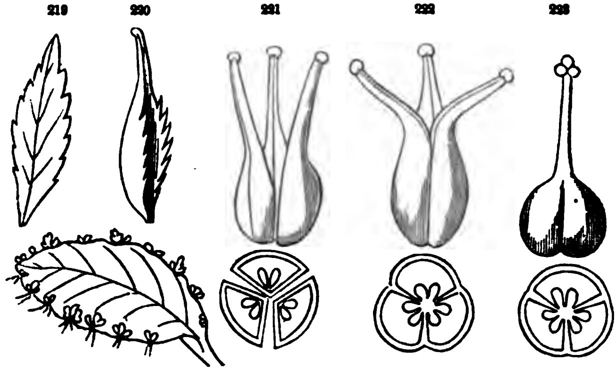
of the style, consisting of a part, or sometimes a mere point of the latter, divested of epidermis (38), with its moist cellular tissue exposed to the air. The ovary, which contains the young seeds, or ovules, is of course a necessary part of the pistil: the stigma, which receives from the anthers the pollen (350) by which the ovules are fertilized, is no less necessary: but the intervening style is no more essential to the pistil than the filament is to the stamen, and is therefore not uncommonly wanting. In the latter case, the stigma is *sessile* upon the apex of the ovary; or, in one instance (Tasmannia), it occupies the side of the ovary nearly its whole length, and is separated from the line to which the ovules are attached only by the thickness of the walls. The style sometimes proceeds from the side, or even from the apparent base of the ovary; as in the Strawberry (Fig. 558).

358. To attain a correct morphological view of the simple pistil, we must contemplate it as resulting from the transformation of a leaf which is folded inwards, and the margins united. The line formed by the union of the margins of the leaf is called the *inner* or *ventral suture*, and always looks towards the axis of the flower. The opposite line, which represents the midrib (151), is termed the *outer* or *dorsal suture*. The surface of the pistil necessarily corresponds to the lower, and its lining to the upper surface of a leaf. The stalk of the pistil, when it is present, represents the petiole; and a prolongation of the apex of the metamorphosed leaf forms the style. The stigma doubtless occupies some portion of what in the style answers to the confluent margins of the transformed leaf (and certainly is not a portion of the midrib, as has been thought); this is evident in Tasmannia, above mentioned, where these margins are actually *stigmatic* for their whole length, and scarcely less so in the numerous cases (in the Chick-

weeds and Pink, for example) where the stigma occupies the whole inner face of the styles; this portion answering to the margins of the leaf in the style, just as the ventral suture does in the ovary.

359. The bodies, called OVULES (289), contained in the ovary, which are the rudiments of seeds, are in all ordinary cases borne on the part which represents the margins of the transformed leaf. They are in some sort analogous to buds, which are occasionally developed on the margins of ordinary leaves; as in the well known case of Bryophyllum (Fig. 224). Since both margins of the infolded leaf may bear ovules, the latter are typically arranged in two rows (one for each margin) on the inner or ventral suture; as is seen in the diagram, Fig. 225, which represents a trans-

219 220 221 222 223



224 225 226 227

FIG. 219. A leaf which stands in the place of the pistil in the Double Cherry (322). 220. A pistil of the same, half changed into a leaf, showing that the pistil is formed of a leaf folded inwards. 224. A leaf of Bryophyllum producing buds along the margins. 221. A whorl of three pistils, the line which passes down the inner side representing the ventral suture (358). 225. A cross section of their ovaries, showing the two rows of ovules, or rudimentary seeds, occupying the inner angle, or ventral suture. 222. A whorl of three pistils, their ovaries united. 226. A cross section of the same. 223. Three pistils with their styles also united quite to the summit. 227. A cross section of the united ovaries.

verse section of the whorl of three ovaries placed above them (Fig. 221).

360. The line or ridge to which the ovules are attached, and which often projects more or less into the cavity of the ovary, is called the PLACENTA. As it corresponds with the ventral suture, and is in fact a part of it, or a development from it, it is always placed next the axis of the flower; as is evidently the case when two, three, or more pistils are present (Fig. 221–227), and is also to be ascertained from the relative position of parts, even when the gynæcium is reduced to a single pistil, as in the Pea tribe. Each placenta necessarily consists of two parts, one belonging to each of the confluent margins of the transformed leaf.

361. The ovules sometimes occupy the whole length of the ventral suture; but frequently they are only produced at its base, or summit. They are sometimes indefinite in number, and are often reduced to a single one.

362. When the pistils are all distinct, they are said to be *apocarpous:* when they are united and form a compound pistil, they are *syncarpous.*

363. Each simple pistil, or each element of a compound pistil, in other words each transformed leaf of the *gynæcium* (288), is termed a CARPEL.

364. All degrees of union of the carpels may be observed, from the mere cohesion of their contiguous inner angles, to the perfect consolidation of the ovaries while the styles remain distinct (Fig. 443, &c.), or of the latter also (Fig. 845). Rarely the stigmas or styles are united while the ovaries remain distinct, as in Asclepias and Apocynum (Fig. 824).

365. The regular structure of a compound pistil is readily deducible from that of the carpels, or simple pistils, which compose it. If the contiguous parts of a whorl of three or more carpels cohere, the resulting compound ovary

will have as many cavities, or cells, as there are carpels in its composition, and the placentæ will all be brought together in the axis; as is shown in Fig. 221–227, where Fig. 225 is a diagram of a cross section of the three contiguous but distinct carpels represented in Fig. 221, while Fig. 226 and 227 are similar diagrams of the three carpels when united. When the whorl is reduced to two carpels, these are uniformly placed opposite each other. The partitions which divide the compound ovary into cells are evidently composed of the united contiguous portions of the walls of the carpels. These partitions, called *dissepiments*, necessarily consist of two layers, one belonging to each carpel; they are always vertical, and are equal in number to the carpels of which the compound pistil is constructed.

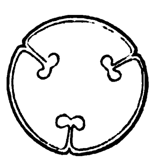
366. A single carpel, therefore, has no proper dissepiment. It is, however, sometimes divided by spurious partitions, separating the cavity into separate cells or joints, placed one above another, as in some species of Cassia, in Desmodium (Fig. 258–260), &c., or even by a vertical false dissepiment produced by the introflexion of the inner or placental suture, as is partially the case in some species of Phaca and Oxytropis (Fig. 263), or by a projection from the dorsal suture, as in the Flax (Fig. 474, 475), the Service-Berry, and many species of Vaccinium, or by its mere introflexion, as in Astragalus (Fig. 262).

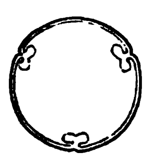
367. A compound pistil, however, is not always several-celled; but two or more carpels may combine to form a one-celled ovary. If we suppose a whorl of three carpellary leaves, with their margins turned inwards, yet not so as to reach the axis, to cohere merely by their contiguous inflexed portions, a one-celled tricarpellary ovary would result, with three imperfect dissepiments projecting into the cavity, but not dividing it into distinct cells (as in the diagram, Fig. 228). The placenta are here borne upon the

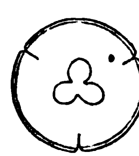
extremity of the imperfect dissepiments, which, if somewhat prolonged, would meet and unite in the centre, so as to present the regular three-celled structure (as in Fig. 444). Frequently, however, these imperfect partitions are also wanting, and the ovule-bearing margins of the carpellary leaves adhere to those of the adjacent carpels, with scarcely any introflexion, forming a one-celled tricarpellary ovary with no appearance of dissepiments (Fig. 229), as in Fig. 432. Such compound ovaries may consist of two carpels, as in Polanisia (Fig. 421), the Currant and Gooseberry (Fig. 587), Epiphegus (Fig. 716), &c., or of four, five, or more.

368. In these cases, the placentæ are said to be *parietal;* being borne upon the walls, instead of in the axis of the compound ovary; and all gradations may be observed between strictly parietal placentæ (as in Fig. 229) and those which are carried inwards nearly or quite to the axis.

369. An ovary with truly parietal placentæ is of course one-celled; except it be divided by a false partition, as in all Cruciferous plants (Fig. 416), &c.


228


229


230

370. Parietal placentæ are double, like those in the axis of a compound ovary of several cells, or of a simple ovary; but with this difference, that in these cases the two portions

FIG. 228–230. Diagrams illustrating parietal and free central placentation. 228. Cross section of an ovary composed of three united carpels, where the introflexed portions do not reach the centre. 229. Section of a similar ovary, except that the placental margins unite without any introflexion (placentæ strictly parietal). 230. Section of a tricarpellary, with a free central placenta, produced by the obliteration of the dissepiments.

belong to the two united margins of the same carpel (363); while in parietal placentæ they are formed from the coherent margins of two adjacent carpels. This will readily appear on comparing the diagrams, Fig. 225, 226, with Fig. 228, 229.

371. Sometimes a compound ovary is one-celled, while the placentæ are in the axis, as in Primula and Anagallis (Fig. 695, 700), an anomaly which is readily explained by supposing the dissepiments to have been obliterated (Fig. 230); as is evidently the case in the Pink tribe, where the remains of the dissepiments may commonly be observed, at least in the early state.* The placentation in such cases is said to be *central* and *free*.

* This mode of placentation is differently explained by those who adopt the new theory respecting the origin of the placenta, recently proposed in Germany, and sustained by many botanists of high authority. According to this view, ovules are deemed to be a peculiar modification of buds: and, as buds regularly arise from the axil of leaves and from the extremity of the stem or axis (71), and only in some exceptional and abnormal cases from the margins or surface of leaves; so ovules are considered to arise from the axis of the flower, like terminal buds, or from the axils of the carpellary leaves, like axillary buds. Thus placentæ are supposed to belong to the axis, and not to the carpellary leaves; and a one-celled ovary, with one or more ovules arising from the base of the cell, would nearly represent the typical state of the gynæcium. This theory, which the intelligent student may easily apply in detail, offers the readiest explanation of free central placentation, especially in such cases as Primula, &c., where not the slightest trace of dissepiments is ever discoverable. It is also perfectly applicable to ordinary central placentation; where we have only to suppose the cohesion of the inflexed margins of the carpellary leaves with a central prolongation of the axis or receptacle, which bears the placentæ. But in case of parietal placentation, the advocates of this theory are obliged to

372. The number of carpels of which a compound ovary consists is indicated by the number of true dissepiments when these exist (365); or by the number of placentæ, when these are parietal (368); and likewise by the number of styles or stigmas, when these are not wholly united into one body. Thus a simple pistil has a single cell, a single placenta, and a single style. A pistil of two carpels may be two-celled, with two placentæ, and two styles, &c.*

---

suppose, that the axis divides within the compound ovary into twice as many branches as there are carpels in its composition, and that these branches regularly adhere, in pairs, one to each margin of all the carpellary leaves. Its application is attended with still greater difficulties in the case of simple and uncombined pistils, where the ovules occupy the whole inner suture, which are doubtless justly assumed as the regular and typical state of the gynæcium; but to which the new hypothesis can be adapted only by supposing that an ovuliferous branch of the axis enters each carpel, and separates into two parts, one cohering with each margin of the metamorphosed leaf. This view, however, not only appears very improbable, but may perhaps be disproved by direct observation, as it has been most completely by those monstrosities in which an anther is changed into a pistil, or even one part of the anther is thus transformed and bears ovules, while the other, as well as the filament, remains unchanged; — a case where the formation of the placenta from a process of the axis is out of the question. This hypothesis is, therefore, entirely untenable as a general theory; and whether it affords a correct explanation of any form of central or basilar placentation must be left for further observation to determine. It must be admitted that the monstrosities which occur in Primula, and some other plants with free central placentation, favor this new view.

* These statements require some qualification, or more detailed explanation. 1. The placentæ being double (360), it occasionally happens that the two portions are separated, as in many Orobanchaceous plants, where a dicarpellary ovary appears on this account to have four parietal placentæ. 2. The stigma, which is

374. When the styles are separate towards the summit, but united below, they are usually described as a single organ; which is said to be *parted*, *cleft*, *lobed*, &c., according to the extent of cohesion. This language was adopted, as in the case of leaves (155) and floral envelopes (300, 303), long before the real structure was understood: but as

---

the only essential part of the style, doubtless belongs, like the placenta, to the margins of the infolded leaf (358); these margins being *ovuliferous* in the ovary and *stigmatiferous* in the style; so that the stigma corresponds to the placenta, and is typically double, like the latter; as Mr. Brown, the most profound botanist of this or any age, has clearly shown. These two constituent portions of the style or stigma are usually combined; but are not unfrequently separate, either entirely or in part, as in Euphorbiaceous plants, in Grasses, and especially in Drosera, where there are consequently twice as many nearly distinct styles as there are parietal placentæ in the compound ovary. If the two component parts of the style of each carpel were here united into one, in the usual manner, their number would equal the placentæ, and their position would be alternate with the latter. But since, in parietal placentation, each *half-placenta* is confluent, not with its fellow of the same carpel, but with the contiguous *half-placenta* of the adjacent carpel (370), it were surely no greater anomaly for the *half-stigmas*, as in Drosera, to follow the same course. This is precisely what takes place in Parnassia, and in other cases where the stigmas are opposite the parietal placentæ; — cases which were thought to be very anomalous, merely on account of the adoption of a false principle (that of the necessary alternation of the stigmas and placentæ), but which are really no more so than the parietal placentation itself. 3. In several well known instances, the whole surface of the ovary is ovuliferous: in Butomus, the Water-Lily (Fig. 396), and some other plants, the whole face of the dissepiments is covered with ovules; while in Brasenia (Fig. 386) and Cabomba, the ovules are all attached to the dorsal suture; — in other words, to the midrib of the metamorphosed leaf!

it conveys an entirely erroneous idea, the expressions, *Styles distinct; united at the base; united to the middle*, or *summit*, &c., as the case may be, should be employed in preference.

375. As a general rule, ovules and seeds are produced and matured within an ovary, or closed carpellary leaf: but in the Blue Cohosh, Leontice (Caulophyllum) thalictroides, the ovules rupture the ovary immediately after flowering, and the seeds become naked; and in the Mignonette they are imperfectly protected, the ovary being open at the summit from a very early period. A more remarkable exception is presented by two natural families, the Coniferæ (Pines, Firs, &c., Fig. 959, 966), and the Cycadaceæ (Cycas, Zamia, Fig. 972); in which the carpellary leaves are flat and open, and consequently the ovules and seeds entirely naked. On this account they have received the name of GYMNOSPERMOUS PLANTS.

§ 7. OF THE OVULE.

376. OVULES, the rudiments of future seeds (289, 359), at first appear like minute pulpy excrescences of the placenta (360); but before the flower expands they have acquired a regular, and generally round or oval form. They are attached to the placenta by one extremity, either directly, or by a short stalk called the *funiculus*, or *podosperm* (Fig. 234, 434). As to number, they vary from one in each ovary (Fig. 877), or in each cell of the compound ovary (Fig. 616, 890), to several or many upon each placenta. In the former case they are said to be *solitary*: in the latter, they are *definite* when their number is uniform and not remarkably great; and *indefinite*, when they are too numerous to be readily counted.

377. As to situation and direction with respect to the

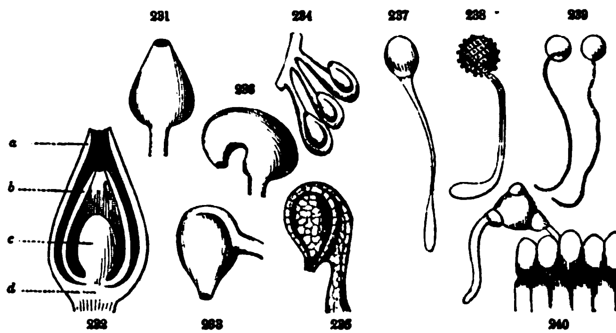
cavity that contains them, ovules are said to be *erect* when they arise from the bottom of the ovary (Fig. 863); *ascending*, when fixed to the placenta above the base and directed upwards (Fig. 564); *horizontal*, when they project from the side of the cell without turning either upwards or downwards (Fig. 844); *pendulous*, when their direction is downwards; and *suspended*, when they arise from the summit of the ovary and hang perpendicularly in the cavity (Fig. 616, 877). In the Thrift (Fig. 711), the ovule is singularly pendent from an ascending funiculus. These terms are applicable to the seed as well as to the ovule.

378. The full-grown ovule consists of two coats or coverings, called the PRIMINE and SECUNDINE (Fig. 232, *a*, *b*), one within the other, inclosing a pulpy, cellular mass, called the NUCLEUS (*c*). The coats or sacs are both open at the apex, and the summit of the nucleus is directed towards these apertures. The orifice of the primine is called the EXOSTOME (or outer mouth); that of the secundine, the ENDOSTOME (or inner mouth): they are at first large and separate; but contract as the ovule becomes a seed, and are brought into contact, when the small aperture which may still be perceived, or at least the scar indicating its position, is termed the FORAMEN, or MICROPYLE. The coats of the ovule and the nucleus are distinct and unconnected, except at the base, or point of attachment to the funiculus, where they are all perfectly confluent: this point of union receives the name of the CHALAZA (Fig. 232, *d*).

379. Through the funiculus and chalaza the ovule derives its nourishment from the placenta; through the opening at the summit, the nucleus receives the influence of the pollen, which results in the production of the embryo.

380. We have described the ovule in its simplest form; where no change in the position of parts takes place during its growth, the chalaza remaining next the placenta, with

which the funiculus directly connects it, while the apex, represented by the foramen (378), or orifice of the coats, is at the opposite extremity. Such an ovule, not being curved or turned from its original or natural direction, is called *atropous* (literally, not turned), or usually *orthotropous* (straight). This simple orthotropous form occurs in the Cistus and Polygonum tribes (Fig. 434), and in many others.



381. More commonly, however, a change takes place during the development of the ovule; consisting either in its complete inversion upon the funiculus that bears it, so that the orifice or apex is brought down by the side of the stalk and points towards the placenta, while the chalaza looks in the opposite direction (as in Fig. 234, 235); or else the ovule curves upon itself, and thus brings down the apex near the funiculus, as in Fig. 236. In the former

FIG. 231. An orthotropous ovule. 232. Longitudinal section of the same, more magnified: *a*, the primine; *b*, the secundine; *c*, the nucleus; *d*, the chalaza. 233. An amphitropous ovule. 234. Three anatropous ovules, with their funiculi, attached to a portion of the placenta. 235. One of the same, more highly magnified, exhibiting its cellular structure. 236. A campylotropous ovule.

FIG. 237. A pollen-grain of Datura Stramonium, emitting its tube. 238. Pollen-grain of a Convolvulus, with its tube. 239. Other pollen-grains, with their tubes, less strongly magnified. 240. A pollen-grain of the Evening Primrose, resting on a portion of the stigma, into which the tube emitted from one of the angles penetrates; the opposite angle also emitting a pollen-tube.

case, the ovule is *anatropous*, or inverted; in the latter, it is *campylotropous*, or curved. Campylotropous ovules are found in the Mignonette, in all Cruciferous and Caryophyllaceous plants, and many others; but the anatropous form is by far the most common of all.

382. In anatropous ovules, the funiculus coheres firmly with that part of the surface which is applied to it; and in the ripe seed breaks away at the point where it is free from the integument, to which the adherent portion remains attached. The latter receives the name of RAPHE; and appears in the form of a ridge, cord, or line, passing from the HILUM (as the scar left by the breaking away of the funiculus from the seed is termed) to the chalaza, maintaining the communication between the interior of the ovule or seed and the placenta. The raphe is only found in the anatropous ovule, and serves to distinguish it; since in all others the hilum or scar exactly corresponds to the chalaza; while in this they occupy the two extremities of the seed; the chalaza, which is the real base, being by this inversion situated at the apparent apex; and the hilum close beside the orifice, micropyle, or organic apex, is the apparent base. This structure, which is in most treatises described in a manner that renders the whole subject difficult, or almost unintelligible to the student, is perfectly simple on the supposition that an anatropous ovule is produced by the mere adhesion of the funiculus to the whole length of one side of an orthotropous ovule.*

383. What are called *amphitropous* or *heterotropous* ovules, which are straight, with the chalaza at one end, the

---

* In the Gooseberry and Currant, which have anatropous ovules (Fig. 591), the ripe seeds commonly become *orthotropous* by the separation of the raphe from the seed-coat to which it was attached; as in Fig. 593.

micropyle or apex at the other, and the hilum half way between the two (as in Fig. 233), arise from the adhesion of the funiculus for a short distance only, forming a raphe of only half the length of the ovule. As the free funiculus in such cases generally diverges at right angles from the axis of the ovule, so that its proper base and apex become lateral, these ovules or seeds are sometimes termed *peltate*, or *transverse*.

384. Campylotropous ovules (Fig. 384) only differ from the orthotropous in being curved during their growth, so that the orifice or apex is brought into juxtaposition with the base; which in this case is both hilum and chalaza.

385. It is important to notice the situation of the orifice, or foramen, of the ovule, as it indicates the future position of the radicle of the embryo (449), which is invariably directed towards the foramen. Its situation with respect to the hilum varies in the different kinds of seeds: in those which arise from orthotropous ovules, it points in the direction exactly opposite the hilum; in the anatropous form, it is brought close to the hilum, so that it is ordinarily said to point to it; in campylotropous seeds it is also brought round to the hilum; while in the amphitropous, it points in a direction nearly at a right angle with the hilum.

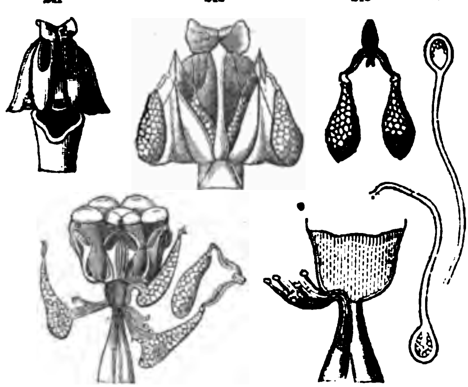
§ 8. Fertilization.

386. A general idea of what is known respecting the action of the pollen in fertilization, and the origin and formation of the embryo, separated from all theoretical considerations and disputed points, may be expressed in few words.

387. Shortly after reaching the stigma, the Pollen-grains emit, through an opening in the outer coat, a tube of extreme tenuity (353), which is a prolongation of its delicate

inner lining (Fig. 237–240, 246, 249), and is filled with the fluid and molecular matter that the grain contains (351). These tubes, as they lengthen and grow, penetrate the loose tissue of the stigma (Fig. 240), and glide along the cells through the interior of the style quite to the placenta, or some other part of the cavity of the ovary (Fig. 248). The foramen of the ovules (378), or a projecting elongation of their nucleus, is at this period brought into contact with, or proximity to, that portion of the walls of the ovary from which the pollen-tubes emerge; and a pollen-tube thus reaches the nucleus, in which the nascent embryo subsequently appears.

241 242 243 247



244 245 246

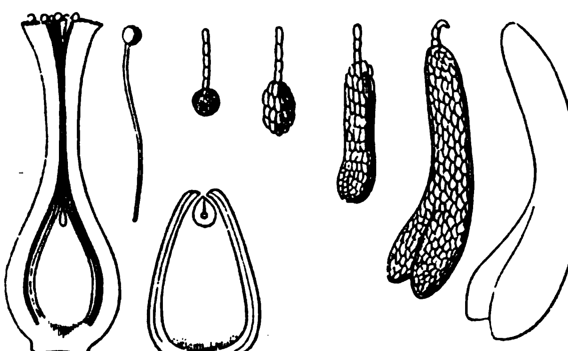
FIG. 241. A back view of a stamen of the common Milkweed (Asclepias), the appendage cut away. 242. A stamen more magnified, with the two pollen-masses cohering by their *caudicles*, each to a gland from the summit of the stigmatic body, to which a pollen-mass from an adjacent anther is already adherent. 243. A pair of detached pollen-masses (each from a different anther) suspended by their caudicles from the gland. 244. Some of the pollen-masses, with their tubes penetrating the stigma (after Brown). 245. A section through the large stigmatic body and a part of the summit of one of the styles, showing the course of the pollen-tubes. 246, 247. Pollen-grains with their tubes, highly magnified. (The structure of these singular flowers will be more fully explained under the order *Asclepiadaceæ*.)

388. The pollen-tubes may be readily inspected under the microscope in many plants; in none more readily than in the Asclepias, or Milkweed, one of the plants in which this subject was so beautifully investigated by Mr. Brown. In that family, the pollen-grains of each cell of the anther (Fig. 241) cohere in a mass; and these pollen-masses, dislodged from their cells (Fig. 242, 243), usually by the agency of insects, and brought into proximity with the base of the stigma, protrude their tubes in great abundance, and of a size which renders them visible with a very moderate magnifying power. They may readily be seen to penetrate the base of the stigma, as in Fig. 244, and separate grains with their tubes may be detached from the mass (Fig. 246, 247); but to trace their course down the style (as in Fig. 245), and to their final destination, requires much tact in manipulation and the best means of research.

389. Usually, a cavity or sac filled with fluid (the *sac of the Amnios*) appears in the nucleus of the ovule before the pollen-tube reaches it, which at length it frequently, and perhaps always, does. A series of minute cells appear in this embryo-sac, usually placed end to end, and forming a thread pendent from the summit of the cavity, or from a point adjacent to the extremity of the pollen-tube. A larger cell, which soon contains minute granular matter, developes at the end of this *suspensor* (Fig. 250, 251). This cell appears to be the embryo in its simplest and most rudimentary state, that of a single vesicle of cellular tissue, containing the organizable materials of new cells. In this state, it probably represents the *spores* (472) of the lowest Cryptogamous plants. In its embryonic development, its contents soon become organized into new cells (20), which increase in number and size, and obliterate the mother cell. The mass at first is commonly globular (Fig. 251), but it early begins to assume its ultimate form. In a dicotyledonous

species, the end farthest from the suspensor begins to be two-lobed (Fig. 253); the lobes increase by ordinary cellular growth, and form the *cotyledons* (Fig. 254); the opposite extremity is of course the *radicle* (43–45); and the suspensor usually disappears before the embryo has attained its full development (Fig. 255).

248 249 251 252 253 254 255



250

390. The embryo is sometimes arrested at a much earlier stage in its development than others, so that its component parts do not appear, or are not recognizable, in the seed. It often takes a further development, and forms its cotyledons into evident leaves, or displays the rudiments of the next succeeding leaves. But at some particular stage it assumes the latent condition which it retains until its further development in germination (451).

FIG. 248. Plan of a vertical section of the pistil of a Polygonum, and of the erect orthotropous ovule it contains, at the period of fertilization: the grains of pollen resting on the stigma have sent their tubes down the style to the mouth of the ovule: and the nascent embryo-sac is seen at the apex of the nucleus. 249. A pollen-grain detached, with its tube. 250. Plan of the vertical section of the ovule more magnified, and at a later period than in 248: the embryo-vesicle with its suspensor seen in the embryo-sac. 251. The nascent embryo with its suspensor more magnified. 252–254. Views of the successive development of the embryo. 255. The embryo as it exists in the seed.

391. Two or more embryos are occasionally and abnormally found in the same seed, in the Orange, the Onion, and many other cases. There are generally two embryos in the seeds of the Mistletoe; and there is constantly a plurality of embryos in Pines and other Coniferous as well as Cycadaceous plants (375), though all but one are more commonly abortive or rudimentary.

CHAPTER X.

OF THE FRUIT.

§ 1. Its Structure, Transformations, and Dehiscence.

392. The fertilized ovary soon begins to increase in size, and commonly to undergo some change in texture; sometimes becoming dry and membranaceous, crustaceous, or even woody, or else gradually changing to fleshy, pulpy, or juicy: it is now called the Pericarp, or seed-vessel. The pericarp and the seeds it incloses together constitute the Fruit; a term which has a more extensive signification in botanical than in ordinary language; being applied to all mature pistils, of whatever form, size, or texture.

393. When the floral envelopes are not adherent to the ovary, they usually wither or fall away soon after its fertilization: but when coherent with its surface (303) in the flower, they are incorporated with the fruit. Thus, nearly the whole bulk of the apple (Fig. 567), pear, and quince (Fig. 564), is a thickened and fleshy calyx. Those fruits of which the calyx forms a constituent part (such as the gooseberry, melon, and cucumber, in addition to those just

mentioned), having a larger number of transformed leaves in their composition, and a more extensive connection with the branch than those which consist of the pistil only (such as the grape, plum, apricot, &c.), are on this account more vigorous than the latter under similar circumstances, and less liable to drop off, or suffer injury from unfavorable weather.

394. The accumulation of fleshy or pulpy matter, which is commonly thought essential to the fruit, sometimes takes place in adjacent organs wholly unconnected with the pistil; as in the free calyx of the Strawberry Blite (Blitum, Fig. 852), which becomes greatly thickened, red, and juicy; and in the Wintergreen (Gaultheria procumbens, Fig. 664–667); where the calyx, at first small and membranaceous, and entirely free from the ovary, gradually enlarges after flowering, and is transformed into a red, pulpy berry, surrounding the true fruit, which is small and dry. The pulp of the strawberry, moreover, is no part of the proper fruit; but consists of the enlarged and juicy receptacle, or apex of the flower-stalk, bearing the numerous small and dry grains, or true fruits, upon its surface (417). The bread-fruit and the pine-apple are still more complex, being composed of a whole head or spike of flowers, with their bracts and common receptacle all consolidated into a single fleshy mass. The mulberry is a multiple fruit of the same kind (Fig. 164), in which the component parts may readily be identified. The structure of the fig, which may be likened to a mulberry or a bread-fruit, turned inside out, has already been explained (270).

395. The growing fruit attracts its food from surrounding parts in the same manner as leaves. When the pericarp preserves its green color and leaf-like texture (as in the Pea, &c.), it is furnished with stomates (142), and acts upon the air like ordinary leaves. Those which become

fleshy or juicy acquire that condition by the accumulation of elaborated sap in their tissue; where it undergoes various transformations, analogous to those which take place in other parts of the plant.

396. Most pulpy fruits are tasteless or slightly bitter during their early growth; at which period their structure and chemical composition is similar to that of leaves, consisting chiefly of fibrous and cellular tissue; and their action upon the atmosphere is likewise the same (224).

397. In their second stage, they become sour, from the production of acids (228), such as tartaric acid in the grape; the citric in the lemon, orange, and the cranberry; the malic in the apple, gooseberry, &c. At this period they exhale very little oxygen, or even absorb that substance from the surrounding air. The acid increases until the fruit begins to ripen, when it gradually diminishes, and sugar is formed.

398. In the third stage, or that of ripening, the acid, as well as the fibrous and cellular tissues, gradually diminish as the quantity of sugar increases; the latter being produced at the expense of the former, by transformations which are very intelligible to the chemist, and which he can partially imitate. A chemical change similar to that of ripening takes place when the green fruits are cooked; the acid and the mucilaginous or other products, by the aid of heat reacting upon each other, are both converted into sugar.

399. A part, and sometimes the whole, of the nutritive matter collected in the pericarp is absorbed by the placenta (360) and conveyed to the seed; where the portion which is not required for its growth is stored up, either in the embryo or around it, as a provision for its future development in germination.

400. The fruit, being merely the matured pistil, should

accord in structure with the latter, and contain no organs or parts that do not exist in the fertilized ovary. Some alterations, however, often take place during the growth of the fruit, in consequence of the abortion or obliteration of parts. Thus, the ovary of the Oak (Fig. 929) consists of three cells, with a pair of ovules in each; but the acorn, or ripened fruit, presents a single cell, filled with a solitary seed (Fig. 932). In this case, only one ovule is matured, and two cells and five ovules are suppressed. The ovary of the Horse-Chestnut and Buckeye is similar in structure (Fig. 504 – 506), and seldom ripens more than one or two seeds: but the abortive seeds and cells may be detected in the ripe fruit. The ovary of the Birch (Fig. 939) is two-celled, with a single ovule in each cell: the fruit is one-celled, with a solitary seed; one of the ovules or young seeds being uniformly abortive, while the other in enlarging pushes the dissepiment to one side, so as gradually to close the empty cell (as Fig. 941). The Elm presents a similar case (Fig. 890, 891); and such instances of suppression in the fruit of parts actually extant in the ovary are not uncommon.

401. On the other hand, the fruit sometimes exhibits more cells than the pistil; as in the two-celled ovary of Datura Stramonium, which becomes spuriously four-celled by the projection of the placentæ on each side, so as to reach and cohere with the dorsal suture.

402. During maturation, the walls of the pericarp sometimes preserve a nearly uniform texture throughout, becoming either entirely membranaceous, as in many capsules or pods; or fleshy, as in the berry; or indurated throughout, as in the acorn. But frequently different parts of the walls undergo a dissimilar transformation; the inner portion hardening while the exterior becomes fleshy, or *vice versâ*. When the walls of a pericarp are thus distinguished into

two separable portions, the exterior receives the name of EPICARP, or EXOCARP, and the interior that of ENDOCARP, or *putamen*. When they consist of three portions, the intermediate, being generally fleshy or pulpy, is termed the SARCOCARP. Thus, in the peach (Fig. 265) and plum, the outer skin is the *epicarp*, the hard shell which contains the seed is the *endocarp*, and the pulpy flesh between the two the *sarcocarp*.

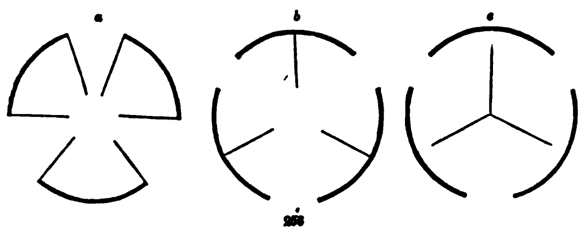
403. The mature fruit often remains closed, as in the acorn, apple, grape, &c.; when it is said to be *indehiscent*. In other cases it separates (wholly or partially) into several pieces, and discharges the seeds; sometimes bursting irregularly, but commonly opening in a uniform and regular manner for each species; when it is said to be *dehiscent*.

404. Regular DEHISCENCE takes place in a vertical direction, by the opening of one or both sutures (358), or by the disunion of confluent parts (365). The pieces into which a dehiscent pericarp separates are called its *valves*.

405. A simple carpel dehisces either by the opening of the inner or ventral suture, as in Aquilegia (Fig. 354); or by the dorsal suture also, as in the Pea and Bean.

406. In a pericarp formed by the union of two or more carpels, the dehiscence may take place by the separation of the constituent carpels from each other, and by the opening of the ventral sutures, as in the Colchicum (Fig. 1033), Rhododendron (Fig. 663), Hypericum (Fig. 444), and in the diagram (Fig. 256, *a*). In this case, the pericarp splits through the dissepiments; whence the dehiscence is said to be *septicidal*. Sometimes the carpels, although separating from each other in this manner, remain closed or indehiscent, as in the Madder (Fig. 630), the Vervain (Fig. 740), &c.; when the separable carpels are often termed *cocci;* and the fruit is said to be *dicoccous*, *tricoccous*, &c., according to their number.

407. In other fruits arising from a compound ovary, the dehiscence takes place by the dorsal suture of each component carpel, opening directly into the back of the cells, when the pericarp is more than one-celled; whence this dehiscence is said to be *loculicidal* (as in Fig. 464, 781, 790, and the diagram, 256, *b*). In such cases, the dissepiments



remain attached to the middle of each valve. In the Helianthemum (Fig. 433), and many other plants, we have an example of loculicidal dehiscence in a one-celled pericarp with parietal placentæ (368); which in this case are borne directly on the middle of each valve. On the other hand, septicidal dehiscence in a similar pericarp is at once recognizable by the placentæ occupying the margins of the valves.

408. Sometimes the placentæ, being firmly coherent with each other, break away from the dissepiments and remain united in the axis, forming a column, or *columella*, as in Rhododendron (Fig. 663), Polemonium, and Collomia (Fig. 780), &c.

409. Occasionally the dissepiments remain coherent with the axis while the valves separate from them, as in the Morning-Glory (Fig. 795), and in the diagram, Fig. 256, *c*. This modification is termed septifragal dehiscence.

410. In like manner, parietal placentæ occasionally sep-

FIG. 256. Diagrams of the dehiscence of capsules (horizontal sections): *a*, the septicidal; *b*, the loculicidal; *c*, the septifragal.

arate from the valves, forming what has been termed a *replum;* as in Cruciferous plants, and in the Poppy tribe. The same name is applied to the persistent border of the simple pod of Mimosa (Fig. 260), &c.

411. Instead of splitting into separate pieces, the sutures of the pericarp sometimes open for a short distance at their apex only, as in some Chickweeds, and in Tobacco (Fig. 807), and the Primrose (Fig. 696); or by mere points or pores, as in the Poppy.

412. In a few cases, the opening takes place by a transverse line passing round the pericarp across the sutures, so that the upper part falls off like a lid; as in Anagallis (Fig. 700), the Plantain (Fig. 704), the Henbane (Fig. 812), and the Purslane (Fig. 459). In Jeffersonia, the opening extends only half way round the pericarp, and the lid is not detached. This anomalous dehiscence is termed ***circumcissile***, or ***transverse***.

§ 2. Its Kinds.

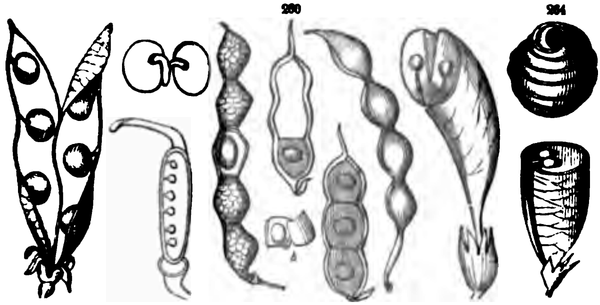
413. The various kinds of fruits have been minutely classified and named; but the terms in ordinary use are not very numerous. The principal kinds may be briefly indicated as follows.

414. A Follicle is a fruit formed of a single carpel, dehiscing by the ventral suture (358), as in the Larkspur and Columbine (Fig. 354), and the Milkweed (Fig. 838).

415. A Legume, or Pod, is a fruit formed of a single carpel, and dehiscent by both the ventral and dorsal sutures, so as to separate into two valves; as in the Bean and Pea. The name is extended to the fruit of all the plants of the Pea tribe (Leguminosæ), whatever be their form, and whether dehiscent or not. A legume, divided into two or more one-seeded joints, and falling to pieces at maturity, is

called a LOMENT, or *lomentaceous* legume. Some of the various kinds of legumes are shown in the annexed figures.

260 264



257 a 258 259 261 262 263

416. A DRUPE, or stone-fruit, is a one-celled, one or two-seeded simple fruit, which is not dehiscent, with the inner part of the pericarp (*endocarp*, stone) hard or bony, while the outer (*exocarp*) is fleshy or pulpy. It is the latter which in our fruits so readily takes an increased development in cultivation. The name is strictly applicable only to fruits of this kind produced by the ripening of a single carpel; as the plum, apricot, peach (Fig. 265), &c.; but is ex-

266

265

FIG. 257. Open legume of the Pea: *a*, section of the ovary. 258. Loment of Desmodium. 259. Loment of Mimosa: *b*, one of its dehiscent joints which has fallen away from the persisting border or frame (replum), seen in 260. 261. The jointed indehiscent legume of Sophora. 262. A legume of Astragalus, cut across near the summit to show how it becomes partly or entirely two-celled by the introflexion of the dorsal suture. 263. Similar view of a legume of Phaca, where the ventral suture is somewhat introflexed. 264. A legume of Medicago lupulina, spirally coiled into a globular figure.

FIG. 265. Vertical section of a peach. 266. An almond; where the exocarp, the portion of the pericarp that represents the pulp of the peach, remains thin and juiceless, and at length separates by dehiscence from the endocarp, or shell.

tended to all one-celled and one or two-seeded fruits of similar texture resulting from a compound ovary, and even to those of several bony cells inclosed in pulp, as in the Buckthorn (Fig. 510), and Dogwood (Fig. 621). The latter, however, are generally said to be ***drupaceous***, or ***drupe-like*** fruits.

417. An Achenium is a small and dry indehiscent one-seeded pericarp, formed of a single carpel; as in the Buttercup (Fig. 350), and the allied genera Anemone and Clematis, where they are often terminated by the persistent and often plumose style, in the form of a long tail. In the Rose (Fig. 563), the achenia are borne on the hollow expansion of the receptacle which lines the fleshy tube of the calyx: in Calycanthus the achenia (Fig. 572) are similarly inclosed in a sort of false pod (Fig. 570, 574) of the same nature as the rose-hip, while in the Strawberry (Fig. 556–558), they are scattered on the surface of the enlarged and pulpy receptacle; where, as in many other cases, they are commonly mistaken for seeds. But they are all furnished with styles, which seeds are not; and on cutting them across we observe the real seed loose in the cell. These seed-like fruits were incorrectly called naked seeds by the earlier botanists. The strawberry, raspberry, &c., therefore, are not simple, but aggregate fruits. In the Raspberry and Blackberry (Fig. 559), the achenia are changed into little drupes (416). The name of achenia is also applied to similar one-seeded fruits resulting from a one-celled ovary, formed of more than one carpel, and invested by the calyx-tube; as that of the Sunflower and all Composite or Syngenesious plants, where the limb of the calyx, assuming a variety of unusual forms, is termed the ***pappus*** (Fig. 656), &c.

418. A Cremocarp consists of a pair of achenia placed face to face, and invested by the calyx-tube; which, when

ripe, separate from each other or from a slender central axis, called the *carpophore;* as in all Umbelliferous plants (Fig. 608 – 615), to which, indeed, the name is restricted. Each separate carpel, or half-fruit, is termed a *hemicarp*, or *mericarp*, and its inner face the *commissure.*

419. A Caryopsis is a thin and membranaceous pericarp, like an achenium, but adherent to the surface of the seed, so as to be inseparable from its proper covering. The grains of Wheat, Maize, and most Grasses, are examples (Fig. 271 – 273).

420. An Utricle is a caryopsis which does not adhere to the seed; as in Chenopodium, &c.

421. A Nut is a hard one-celled and one-seeded indehiscent fruit, like an achenium, but produced from an ovary of two or more cells with one or more ovules in each, all but a single ovule and cell having disappeared during its growth (400); as in the Hazel, Beech, the Oak (Fig. 927), Chestnut, Cocoa-nut, &c. The nut is often inclosed or surrounded by a kind of involucre (268), termed a *cupule;* as the cup at the base of the acorn, or the burr of the chestnut.

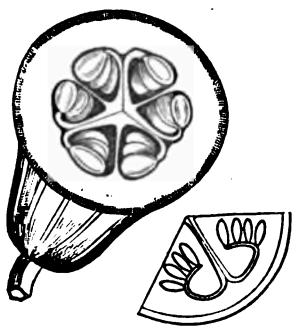
422. A Samara is a name applied to a nut or achenium, having a winged apex or margin; as in the Birch (Fig. 941) and Elm (Fig. 891). The fruit of the Maple consists of two united samaræ (Fig. 498).

423. A Berry is an indehiscent fruit which is fleshy or pulpy throughout; as the grape, gooseberry (Fig. 586), and persimmon (Fig. 688). The orange, sometimes termed a Hesperidium, is merely a berry with a leathery rind.

424. A Pome, such as the apple, pear, and quince (Fig. 564 – 567), is a fruit composed of two or more cartilaginous or bony carpels, usually more or less involved in a pulpy expansion of the receptacle or disk, and the whole invested by the thickened and succulent tube of the calyx. It may

be readily understood by comparing a rose-hip with a haw, a quince, and an apple.

425. A PEPO is an indehiscent fleshy, or internally pulpy fruit, composed usually of three carpels, invested by the calyx, and with a firm rind; as the cucumber, melon, and gourd. Its proper structure, which has been variously misconceived, may readily be gathered from a cross section of a very young melon or gourd (Fig. 267). The three large placentæ project from the axis to the parieties of the cell, where their two constituent parts, more or less separated and recurved, bear the ovules. As the ovary enlarges, the ends of the placentæ usually cohere with the contiguous walls, and the thin dissepiments are at the same time obliterated; so that the fruit presents the deceptive appearance of a three-celled (or, by obliteration of the axis, a one-celled) pericarp with parietal placentæ.



267 268

426. A CAPSULE is a general term for all dry and dehiscent fruits resulting from a compound ovary, whether opening by valves (404, Fig. 444, 454, 464, &c.), or bursting irregularly, as in Lobelia, or shedding the seeds through chinks or pores, as in the Poppy.

427. A SILIQUE is a two-valved pod-shaped capsule, rendered two-celled by a false partition stretched between the parietal placentæ (368), from which the valves separate; as in all Cruciferous plants (Fig. 411), to which family it is confined. A short and broad silique is called a SILICLE; as in the Shepherd's Purse or Capsella (Fig. 416).

FIG. 267. Section of the ovary of the Gourd; and 268, a diagram of one of its constituent carpels.

428. A PYXIDIUM, or PYXIS, is a capsule that opens transversely by a lid or cover, as already explained (412).

428[a]. What are called *collective*, *multiple*, or *anthocarpous* fruits, result from the combination of several flowers into one aggregate body or mass. They are, in fact, masses of inflorescence, with the fruits or floral envelopes coherent with each other; as in the pine-apple, the mulberry (Fig. 164), &c. The grains of the latter are not the ovaries of a single flower, like those of the blackberry (Fig. 559), but belong to as many separate flowers; and the pulp of these belongs to the floral envelopes instead of the pericarp (394). The fig results from a multitude of flowers concealed in a hollow flower-stalk, if it may be so called, which becomes pulpy and edible (Fig. 162). Thus the *fruit* seems to grow directly from the branch without being preceded by a flower. In the Partridge Berry (Mitchella repens), and in several species of Lonicera (Fig. 622), the ovaries of two flowers are uniformly united, so as to form a double berry; just as twin apples or cherries are sometimes accidentally produced.

429. A CONE, or STROBILE, is a collective fruit of the Fir tribe (Fig. 956), &c., and the Cycas tribe (Fig. 968); each scale representing an open carpel (375), bearing one or more naked seeds (Fig. 959). The cone of a Magnolia (Fig. 360), is, however, entirely different, consisting of the numerous aggregated carpels of a single flower, crowded and persistent on an elongated receptacle.

CHAPTER XI.

OF THE SEED.

§ 1. ITS STRUCTURE AND PARTS.

430. The Seed, like the ovule (376), of which it is the fertilized and matured state, consists of a *nucleus*, usually inclosed within two *integuments*.

431. The outer integument, or proper seed-coat, corresponding to the primine (378) of the ovule, is variously termed the *episperm*, *spermoderm*, or more commonly the *testa*. It varies greatly in texture, from membranaceous or papery to crustaceous or bony (as in the Papaw, Nutmeg, &c.), and also in form; being sometimes closely applied (conformed) to the nucleus, and in other cases loose and cellular (as in Pyrola, Fig. 680, and Sullivantia, Fig. 603), or expanded into wings (as in the Catalpa and Bignonia), which render the seeds buoyant, and facilitate their dispersion by the wind; whence winged seeds are only met with in dehiscent fruits. For the same purpose, the testa is sometimes provided with a tuft of hairs at one end, termed a *coma;* as in Epilobium, Asclepias, or Milkweed (Fig. 840), and Apocynum (Fig. 825). In the Cotton-plant, the whole testa is covered with long wool. It should likewise be noticed, that the integument of numerous small seeds (as well as seed-like achenia) are furnished with a coating of small hairs containing spiral threads (one form of which is represented in Fig. 22), and usually appressed and confined to the surface by a film of mucilage. When the seed is moistened, the mucilage softens, and these hairs shoot forth in every direction. They are often ruptured, and the extremely attenuated elastic threads they contain uncoil, and

are protruded in the greatest abundance to a very considerable length. This minute mechanism subserves an obvious purpose in fixing these small seeds to the moist soil upon which they lodge, when dispersed by the wind. Under the microscope, these threads may be observed in the seeds of most Polemoniaceous plants, and in the achenia of Labiate and Composite plants, as, for example, in species of Senecio, or Groundsel.

432. The inner integument of the seed, resulting from the secundine of the ovule, is called the *tegmen*. Although frequently very obvious, it is sometimes undistinguishable, or wanting.

433. Seeds are sometimes furnished with a partial or complete, usually fleshy covering, exterior to their proper integuments, arising from an expansion of the apex of the seed-stalk, or *funiculus* (376), or of the placenta itself when there is no manifest seed-stalk. This substance, called an Aril, forms a complete pulpy envelope in Euonymus and Celastrus, or a mere scale occupying one side of the seed in Turnera, and a tough, lacerated body, known by the name of *mace*, in the Nutmeg.

434. The scar left by the separation of the seed from its funiculus is termed the *hilum*. The relation of the hilum to the *chalaza*, *micropyle* (378), and other parts of the seed, we have sufficiently indicated when considering the structure of the ovule. The chalaza and raphe (382), when present, are commonly obvious in the mature seed, as well as in the ovule.

435. The terms *orthotropous*, *anatropous*, *campylotropous*, &c., originally applied to the ovules, are extended to the seeds which result from them; so that we may say, Seeds anatropous, as well as Ovules anatropous, &c.

436. The Nucleus, or kernel, consists of the *albumen*, when this substance is present in the seed, and the *embryo* (43, 390).

437. The ALBUMEN consists of starch, or other nutritive matter deposited in the tissue of the nucleus of the ovule, and designed both for the protection of the embryo, and for its nourishment during its earliest growth. It commonly (but not always) surrounds the embryo, and is the more abundant as the latter is small and feeble. It is *farinaceous*, or *mealy*, in all Grasses, especially in the grains employed for food, where it makes up the principal bulk of the seed (Fig. 271 – 273); *corneous*, or of the texture of horn, in Leontice, the Coffee, &c.; *oily* in the Poppy, &c.; and *fleshy* in the greater number of seeds. In the Nutmeg and the Papaw, it has a wrinkled or variegated appearance; when it is said to be *ruminated* (Fig. 365).

438. The albumen, not being an essential part of the seed, is entirely wanting in the Pea tribe, in all Cruciferous plants, and in many other families; where the matter of the nucleus is absorbed during the growth of the embryo, and a portion sufficient for the development of the latter in germination is deposited in its own substance. In those seeds which possess no albumen, the embryo occupies the whole cavity, as in Fig. 422, 445, 560, 575, 650, 741, 742, 879, 932, &c. (Some of the sections are longitudinal and show the length of the embryo, others pass tranversely through the cotyledons.) Such seeds are *exalbuminous*. In *albuminous* seeds, a part, and often much the largest portion of the seed is occupied by the albumen; when sections of the seed, so directed as to pass through the embryo (either vertically or horizontally) present such appearances as Fig. 271 – 273 (*a*, the albumen), 381, 435, 448, 456, 471, 489, 527, 592, 604, 618, 626, 631, 668, 689, 690, 718, 796, 809, &c.; varying according to the shape and size of the embryo, its position in the albumen, and the direction of the section.

439. The EMBRYO, being an initial plant or new indi-

vidual, is of course the most important part of the seed; and to its production, protection, and support, all the other parts of the fruit and flower are subservient.

440. The embryo is produced within the sac of the amnios (389), which is usually absorbed during its growth, but sometimes remains in the form of a bag inclosing the embryo; as in the Pepper, in Saururus (Fig. 902), and Brasenia (Fig. 389). When there is no albumen, the whole substance of the nucleus is usually absorbed, and occupied by the embryo.

441. The embryo becomes a plant by the mere development of its parts: it therefore possesses, in a rudimentary or undeveloped state, all the essential organs of vegetation, namely, a root, stem, and leaves (43). In numerous cases, as in the Linden (Fig. 472) and the Convolvulus (Fig. 796–798), &c., these several parts are perfectly distinguishable in the seed; and the seed-leaves are already foliaceous: sometimes they are large, but thickened by the nourishing matter they contain, as in the Almond (Fig. 554), and the Oak (Fig. 983). Frequently, however, we only observe an oblong body, cleft or two-lobed at one end, as in many of the figures recently cited: but in germination the undivided extremity elongates into a root, the two lobes at the opposite end disclose their real nature by expanding into leaves, and the stem rises between them.

442. The two lobes, or rudiments of the first pair of leaves, are termed Cotyledons; the bud, which, if not actually visible in the seed, as in the Almond (Fig. 554, *a*), appears between them when germination commences, is called the Plumule; and the portion below, which gives rise to the root, is named the Radicle.

443. In these illustrations, we have assumed the embryo with a pair of cotyledons to be the typical, as it is the most common form, occuring as it does in all the families of

Exogenous plants (98). Hence the latter are also called Dicotyledonous Plants (100).

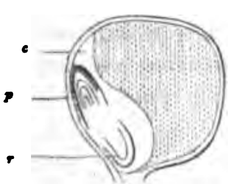
444. But in all Endogenous plants only one cotyledon appears; or, if two are present, one of them is alternate with the other. Hence Endogens are also termed Monocotyledonous Plants. The monocotyledonous embryo does not usually present the same manifest distinction into radicle, cotyledons, and plumule, as the dicotyledonous; but often appears like a homogeneous and undivided cylindrical or club-shaped body (as in Triglochin, Fig. 1003). Not unfrequently, however, a vertical slit, or chink, is observed near the radicular extremity, as in Triglochin, above cited, through which the plumule is protruded in germination. If the embryo be divided parallel with this slit, the plumule is brought into view; as in Fig. 1004. If a horizontal section be made at this point (as in Fig. 1005), the cotyledon is found to be wrapped around the inclosed plumule. The plumule is more manifest in the Grass tribe, especially in the cereal grains (Fig. 271 – 273). In many cases, however, no distinction of parts is apparent until germination.

445. Sometimes the two cotyledons of a dicotyledonous embryo are conslidated, as in the Horse-Chestnut (Fig. 506), where they form one fleshy mass; but the parts are separable during germination.

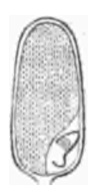
446. The embryo of the Pine and Fir, and many other Coniferous plants, is remarkable for having several cotyledons (Fig. 962). This is the most complex form of the embryo.

447. In the Cuscuta, or Dodder, which never produces foliage, the embryo is also entirely destitute of seed-leaves or cotyledons (64 and Fig. 68). In this instance the embryo is of considerable size, indeed; but in most such parasites, the embryo is very minute, as well as reduced to the greatest degree of simplicity, and seems to remain until germination in a very rudimentary state.

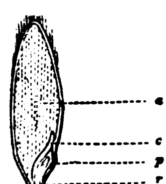
448. The various forms under which the embryo occurs may readily be gathered from the numerous illustrations scattered through the latter part of this volume; which need not be specially enumerated. Its position as respects the albumen, when that is present, is also various. Although more commonly in the axis, it is often *eccentric*, or even external to the albumen, as in all Grasses (Fig. 271 – 273), in Polygonum (Fig. 864), &c. When external or nearly so, and curved circularly around the albumen, as in Fig. 448, 457, 854, 872, and generally in the families from which these illustrations are taken, it is called *peripheric*. When the embryo is bent so that the radicle is placed against the edges of the cotyledons, the latter are said to be *accumbent* (Fig. 412, 413); or when the radicle rests against the back of one of them (Fig. 418), they are called *incumbent:* terms nearly restricted to Cruciferous plants.



271



272



273

449. The situation of the embryo with respect to the base and apex of the seed is so far uniform, that the radicle always points to the micropyle, as already mentioned (385); and the summit of the cotyledons, except when spirally coiled, is invariably directed towards the chalaza.

FIG. 271. Vertical section of a grain of Indian Corn, passing through the embryo: *c*, the cotyledon; *p*, the plumule; *r*, the radicle. (A highly magnified portion of the albumen, which makes up the principal bulk of the grain, is shown in Fig. 43, p. 34.) **272.** Similar section of a grain of Rice. **273.** Vertical section of an Oat-grain: *a*, the albumen; *c*, the cotyledon; *p*, the plumule; and *r*, the radicle of the embryo.

As the nature of the seed may usually, after some practice, be readily determined by external inspection, so the situation of the embryo within, consequently, may often be inferred without actual dissection.

450. The direction of the embryo with respect to the pericarp is also particularly noticed by systematic writers; who employ the terms *ascending*, or *radicle superior*, when the latter points to the apex of the fruit; *descending*, or *radicle inferior*, when it points to its base; *centripetal*, when the radicle is turned towards the axis of the fruit; *centrifugal*, if towards the sides; and *vague*, when it bears no evident or uniform relation of this kind to the pericarp.

§ 2. Germination.

451. Our limits prevent us from illustrating the various arrangements for the natural dissemination of seeds; and from considering the circumstances under which the embryo retains its vitality, in many species ordinarily for a few months only, in some perhaps for many centuries.* We

* It is well known that seeds which have been kept sixty years have germinated; and it seems that grains of wheat, taken from ancient mummies under circumstances of their high antiquity, have been made to germinate; but in these cases there are several causes of possible deception. Dr. Lindley records the remarkable case of some Raspberries, "raised in the garden of the Horticultural Society from seeds taken from the stomach of a man, whose skeleton was found thirty feet below the surface of the earth, at the bottom of a barrow which was opened near Dorchester. He had been buried with some coins of the Emperor Hadrian; *and it is therefore probable that the seeds were sixteen or seventeen hundred years old.*" Most seeds, when buried deep in the soil, where they are subject to an uniform and moderate temperature, and removed from the influence of the air and light, are in a favorable state for the preservation of vitality, and will germinate when brought to the surface after a very long interval.

must briefly notice the conditions under which this latent vitality is called into activity, and the embryo developes into a plant.

452. The conditions requisite to germination are exposure to moisture and to a certain amount of heat, varying from 50° to 80° (Fahrenheit) for the plants of temperate climates, to which must be added, a free communication with the air. Direct light, so essential to subsequent vegetation, is unnecessary, and generally unfavorable to germination. The degree of heat required to excite the latent vitality of the embryo is nearly uniform in the same species, but widely different in different plants; since the common Chickweed will germinate at a temperature not far above the freezing point of water; while the seeds of many tropical plants require a heat of 90° to 110° (Fahrenheit), to call them into action, and are often exposed to a considerably higher temperature. Seeds are in the most favorable condition for germination in spring or summer, when loosely covered with soil, which excludes the light while it freely admits the air, moistened by showers, and warmed by the rays of the sun. The water which is slowly absorbed softens all the parts of the seed; the embryo swells and bursts its envelopes; the radicle is protruded, and, taking a downward direction, fixes itself in the soil; while the other extremity elongates in the opposite direction, bringing the cotyledons (except when these remain under ground, as in the Pea, the Horse-Chestnut, Wheat, &c.) and the plumule, or growing apex of the young stem, to the surface, when the primordial leaves expand in the air. As soon as the root and leaves are developed, each in their appropriate medium, the process of germination is finished; and the plant, deriving through them its nourishment, continues to grow in the manner already described (43).

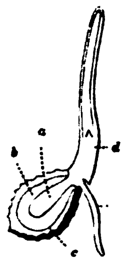
453. The nourishment which the embryo requires during

germination is furnished by the starch, &c., of the albumen (36, 437), when this substance is present in the seed; or by starchy or other matter accumulated in its own tissue. But as starch is insoluble in cold water, certain chemical changes are necessary to bring it into a fluid state, so that it may nourish the embryo. These changes are apparently incited by the agency of *diastase*, a substance probably formed at the expense of the gluten, or other nitrogenized products, which the seed contains (229); and essentially consist in the transformation of the starch first into dextrine, or gum, and thence into sugar (227), a part of which is destroyed by resolution into carbonic acid and water, with the abstraction of oxygen from the air, and the evolution of heat (246), while the remainder is rendered directly subservient to the growth of the plantlet. The reason why light, so essential to subsequent growth, impedes or prevents germination becomes evident when we remember that it incites the decomposition of carbonic acid, and the fixation of carbon by the plant (226); while germination is attended by an opposite transformation, namely, the destruction of a portion of organized matter, and the evolution of carbonic acid.

454. In most Dicotyledonous plants, the cotyledons rise out of the ground, and perform more or less perfectly the office of leaves, until those of the plumule expand (Fig. 52 – 55): but when they are very thick and fleshy, as in the Horse-Chestnut, the Pea, the Oak, &c., they serve merely as reservoirs of nourishment, and remain under ground, the first leaves which appear being those of the plumule. This is also the case in all the Monocotyledonous plants; in which the cotyledon remains within the integuments of the seed, while the radicle and plumule together pass out at or near the micropyle, as in the germinating seed of Scirpus (Fig. 274).

455. Seeds sometimes begin to germinate while attached

to the parent plant, especially such as are surrounded with pulp, like those of the Cucumber and Melon. The process is liable to commence in wheat or other grain, when protracted warm and rainy weather occurs at the period of ripening; and the albumen becomes glutinous and sweet, from the partial transformation of the starch into gum and sugar. In the Mangrove, which forms dense thickets along tropical coasts, germination takes place in the pericarp while the fruit remains on the tree; and the radicle, piercing the integuments which inclose it, elongates in the air, until it reaches and fixes itself in the soft mud, where such trees usually grow (62, p. 48).



274

CHAPTER XII.

OF CRYPTOGAMOUS, OR FLOWERLESS PLANTS.

456. Having traced the development, structure, and physiology of the higher, or Flowering Plants, considered as the exponents of the general plan of vegetation (51, 52), we have now briefly to consider the series of simplifications of this plan, or *type*, which occur in what are in a proper sense termed the *lower* plants, and which, by the successive suppression (307), non-development, or leaving out of parts that belong to the fully realized plan, at length reduce the vegetable to the minimum state. In framing our brief account in accordance with this ideal view,—that of a plan, or type, which is realized in Flowering Plants, but which is

FIG. 274. The germinating seed of Scirpus, a Monocotyledonous plant: *a*, the cotyledon, remaining within the albumen, *b*, inclosed in the pericarp, *c*; from which the plumule (*d*) elongates.

gradually reduced and simplified in the lower and humbler vegetable forms, we have to commence with the highest grades, and trace the progress of simplification downwards.

457. The plan in vegetation evidently is, that of an axis, growing downwards into a *root*, and upwards into a *stem* (43); each developing in accordance with an inherent impulse; the former fixing the plant to the soil from which it is to imbibe its crude food; the latter rising to the light of day, so as to expose itself more and more to that influence by whose aid it elaborates this crude food into proper nourishment (220–229). Obedient to this impulse, and in order to expose the greatest possible amount of surface to the light and air, it produces distinct expansions of its green surface in the form of *leaves* (134). And finally, the ascending axis and its branches are terminated by *flowers* (239), of which the essential organs are *stamens* and *pistils* (291), by the instrumentality of which a new individual is originated and developed in the seed into a rudimentary plantlet (439), or *embryo;* in which the new axis, and the first leaf or leaves it is to bear, are already in most cases plainly distinguishable (441).

458. We have already alluded to the occasional simplifications in the organs of vegetation which Flowering Plants sometimes exhibit; as in the Cactus tribe, &c., where there is no obvious distinction of stem and foliage (92, 146); and in Lemna, or Floating Duckweed (Fig. 990), where a foliaceous expansion is at once stem and foliage, the upper surface acting as leaf, while the lower emits rootlets that hang loose in the water. In one class of parasitic plants, the foliage is either omitted altogether, or appears under forms that want the green color, and do not fulfil the essential office of leaves (64, 168). The simplifications or reductions which Flowering Plants exhibit as to their organs of fructification, and of which Lemna, above cited, furnishes

one example, have been fully illustrated in Chapter IX. The greatest simplification compatible with the existence of proper flowers occurs in Coniferous and Cycadaceous plants (375), which are accordingly placed at the very close of the flower-bearing series. Here the staminate flowers are often reduced to a single anther, and the pistillate are uniformly reduced to one or two ovules, borne on an open carpellary leaf, which answers to the pistil, and therefore receiving the influence of the pollen in the most direct mode.

459. At the next step in the downward progression, proper flowers, or organs constructed after this floral type, disappear. Hence the whole lower series of vegetables, all from this point downwards, are distinguished by the general name of FLOWERLESS PLANTS, or by the earlier Linnæan name of CRYPTOGAMOUS PLANTS; the latter denoting figuratively that the flowers are concealed or obscure.

460. There is probable reason for supposing that tribes of plants once existed (at the epoch of the coal formations) which filled the chasm that now separates the Flowerless from the Flowering series, so as to render the transition much more gradual than it now appears. At present we make a somewhat abrupt descent from the tribes of Flowering Plants to Ferns, Equisetums (Horsetails), and Lycopodiums (Ground Pine, or Club-Moss). These exhibit the analogues merely of the essential floral organs, either of one or both kinds; and some produce two sorts of bodies, one of which, it has been thought, answers to pollen, and the other to ovules, or seeds. Perhaps the resemblauce is only one of analogy: in some cases both sorts are well known to germinate and give rise to new plants.

461. We have remarked that the embryo in Flowering Plants is developed in the seed to a very unequal degree in different species or tribes (441–447). In some cases it remains, until germination, either in the earliest rudimental

state, hidden in the seed, or else as a mass of cells without any manifest distinction of parts (390). This appears to be its condition in the Orchis family, and in that group of parasitic plants of which Rafflesia (Fig. 70) is a representative. The seeds of all the higher Flowerless Plants are reduced to a still greater degree of simplicity. They are minute masses of cells, not distinguishable into integument, albumen, and embryo, not distinguishable even into a proper seed-coat and nucleus (430). The mode of formation or origin is also essentially different from that of seeds, and is for the most part conformable with that of pollen-grains (343^{a}), or with one mode of the production of cells (21). Hence the name of seeds, in a strict sense, is denied to the reproductive bodies of Flowerless Plants: they receive instead the distinctive appellation of SPORES.

462. The organs of vegetation do not exhibit any particular tendency to simplification in the highest Flowerless Plants. Some of them are arborescent (Tree Ferns, Fig. 286); but the woody or perennial stems exhibit neither the annual layers of the exogenous, nor that distribution of woody matter which characterizes the endogenous, structure (96 – 99). As the stems grow from the apex alone, and have no provision for continued increase in diameter, these have been called ACROBYA, ACROGENS, or ACROGENOUS PLANTS; a name, however, to which they have no very peculiar claim.

463. With these general prefatory considerations, we may proceed to take a summary view of the particular structure of the different groups of the higher Flowerless, or Cryptogamous, Plants. We shall employ and define only those technical terms which are in common use. The particular glossology of Flowerless Plants must be sought in systematic and special works.

464. The order EQUISETACEÆ, consisting of the *Scouring*

Rushes and *Horsetails*, has been placed at the head of the series, on account of the resemblance which the organs of vegetation and the spike of fructification bear to many Coniferæ, especially to Ephedra and Callitris, and also because the filaments that are attached to the spore (Fig. 280), were mistaken for rudimentary or abortive stamens. Equisetum exhibits hollow, jointed stems, either simple or bearing whorled branches or branchlets, and bearing at the nodes

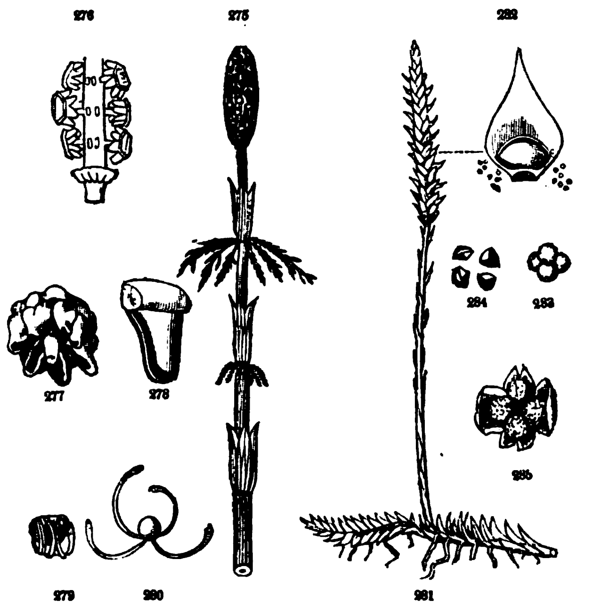


FIG. 275. Summit of the stem of Equisetum sylvaticum. 276. Part of the axis of the cone of fructification, with some of the fruit-bearing organs, shown magnified in Fig. 277. 278. A separate *theca*, more magnified. 279, 280. Spores with elaters, still more magnified.

FIG. 281. Lycopodium Carolinianum of the natural size. 282. A leaf detached from the spike, with the theca in its axil, magnified. 283. Four aggregate spores, magnified. 284. The same separated. 285. Four of the larger spores of Lycopodium apodum, with their irregularly dehiscent theca, moderately magnified.

toothed sheaths in place of leaves (Fig. 275). The fructification is a cone or spike, consisting of peltate scales (Fig. 277), which may be compared with those of Zamia of the Cycas tribe (Fig. 970, 972), and which are attached around a central axis (Fig. 276). These bear on their lower surface several *involucra*, *thecæ*, or *sporangia* (Fig. 278), which open lengthwise along the inner side, and discharge the numerous spores they contain. To the spores are attached four club-shaped filaments (called *elaters*), which when moist are coiled close around the spore (Fig. 279), but which at maturity unroll in dryness (as in Fig. 280), and in an obvious manner aid in the dispersion of the spores. Their origin on a loose membranous coat of the spore, which is soon obliterated in the same manner as in other elaters (469), shows that they are in no respect truly analogous to stamens.

465. The order LYCOPODIACEÆ consists of a set of plants, some of which are familiarly known by the names of *Ground Pine*, and of *Club-Moss*. Their apparent position in the natural series, and their outward resemblance, some of the larger forms to Coniferous plants, and the humbler to Mosses, are shown by these popular names. The fructification consists of solitary sacs (*thecæ*, or *sporocarps*), in the axils of the leaves or bracts (Fig. 282), which open along the upper edge and discharge the innumerable spores they contain. As a consequence of the mode of their production (21), the spores are grouped or coherent in fours (Fig. 283, 284). Some few species bear also a second kind of spores, few in number and at least fifty times larger than the former, which are contained in thecæ that burst irregularly (Fig. 285).

466. The large order of FERNS is remarkable for bearing the fructification upon the leaves, or, as they are technically termed, *fronds*. In this respect, as well as in the palm-like port of its arborescent species (Fig. 286), it may be compared with Cycas, the typical representative of the

lowest order of Flowering Plants, in which the naked ovules and seeds are manifestly borne on the margins of leaves.

286

287

The *caudex*, or proper stem, of most Ferns of the temperate and colder regions, however, instead of rising into a trunk, is subterranean, and is often a creeping rhizoma, as in Polypodium vulgare' (Fig. 287). From it the *fronds* that constitute the foliage arise; and which are remarkable for being coiled spirally, or *circinate* (188), in vernation. Their stalks are called *stipes*, and the divisions of the foliage, like those of a pinnate leaf, are termed *pinnæ*, or *pinnules*. In true Ferns, the fructification is usually borne upon the back or lower surface of the fronds, in the form of dots, lines, or clusters (called *sori*, Fig. 289, &c.) of granules, which spring from the veins or their branches. The *sori* are sometimes protected by a portion of the epidermis (Fig. 289), or by a reflexed portion of the frond, called the *indusium*. When somewhat magnified, the granules are seen to be *thecæ*, or *sporangia*, attached by stalks or otherwise to the veins, and bursting transversely in the largest tribe of the family by the elastic straightening of an incomplete ring, as in Fig. 290, so as to

FIG. 286. Sketch of a Tree Fern, Dicksonia arborescens, of St. Helena; after J. D. Hooker. 287. Polypodium vulgare, with its creeping caudex or rhizoma.

disperse the contained spores (Fig. 291). In another tribe, the sporangia open by a vertical fissure, as in Fig. 294; and there are still other modifications. One is seen in the Adder-

FIG. 288. Asplenium (Camptosorus) rhizophyllum (Walking Fern); the fronds rooting, as they frequently do, at the apex; the sori occupying the reticulated veins on the back. 289. Division (pinnula) of a frond of Aspidium (Nephrodium) Goldianum; the roundish sori attached to the simple veins, and covered with an indusium, which is fastened in the centre, and opens all around the margin. 290. Magnified sporangium of this division of Ferns, with its stalk, and elastic ring partly surrounding it; which, tending to straighten itself when dry, tears open the sporangium, shedding the minute spores (291). 292. Schizæa pusilla of about the natural size, with simple and slender radical leaves; the contracted fertile frond pinnate. 293. A division (pinna) of the fertile frond, magnified, showing the sessile sporangia occupying its lower surface. 294. One of the sporangia more magnified; they have no proper ring, and open by a longitudinal cleft. 295. Ophioglossum vulgatum (Adder-tongue); the sporangia forming a two-ranked spike on a transformed and contracted frond: *a*, portion of the spike enlarged, showing the coriaceous sporangia, destitute of a ring and opening transversely.

tongue (Fig. 295), where the firm and large sporangia, persistent on the margins of a transformed frond, are destitute of a ring, and, opening by a transverse fissure, considerably resemble the thecæ of Lycopodium (Fig. 282).

467. There is still another group of this higher division of flowerless vegetation, consisting of a few aquatic plants, which bear the fructification directly upon the root-like stems, or near the root (whence they have been called RHIZOCARPÆ), and which are deemed to be furnished with two sorts of organs, the direct analogues of stamens and pistils. But, as we are not prepared to illustrate their curious and difficult structure by figures, we shall not here attempt to describe it. Marsilea and Azolla are examples. Although the organs of vegetation are much reduced, as is apt to occur in aquatics, yet their reproductive organs perhaps approach more nearly to the type of flowers than do those of any of the above-mentioned orders.

468. The next considerable step in the downward progression, namely, in MOSSES, is also marked by a great simplification in the organs of vegetation, chiefly as to anatomical structure, while those of fructification are still complex. At this point, woody tissue and vessels disappear, and the universal cellular tissue alone enters into the composition of the lower Flowerless Plants (22, 27, 102). The stem and foliage are still distinct; but the former never has any wood or vessels in its composition, and the leaves consist merely of one or more layers of parenchymatous cells. The analogues of flowers form little clusters concealed among the leaves; the two kinds disposed after a monœcious or diœcious manner, or mingled in the same cluster. The analogues of stamens (*antheridia*, Fig. 296, ♂, and 297) are small cellular sacs, which burst at the apex, and discharge a mucous fluid filled with minute particles: among them cellular, jointed threads (*paraphyses*)

are mingled. The analogues of pistils (Fig. 296, ♀) are bottle-shaped bodies (*pistillidia*, *sporangia*), great numbers of which are abortive. Those that are to come to maturity are soon, for the most part, raised upon a slender stalk (*seta*), carrying with them an outer membranous covering, which in the fruit rests on the summit of the *sporangium*, or *theca*, like a hood (the *calyptra*, Fig. 306, 308, 299), and at length falls away spontaneously. The leaves which surround the base of the seta, or stalk, generally different from the rest of the foliage, are called *perichætial* leaves. The fruit, or sporangium, usually opens at maturity by a lid

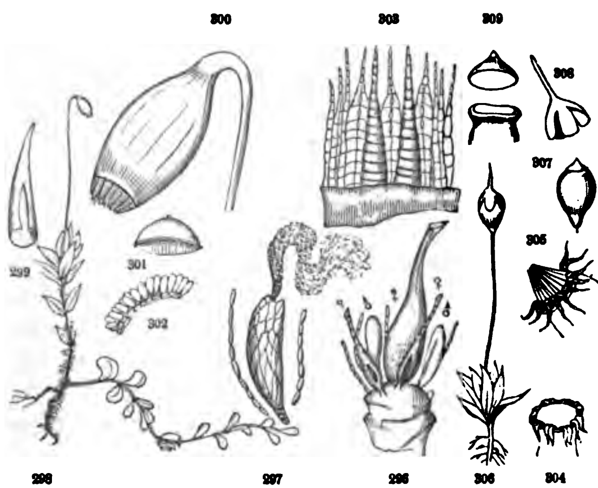
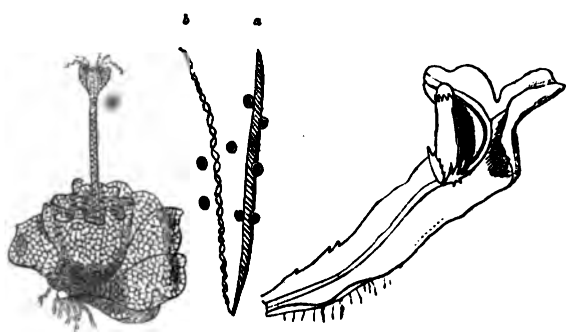


FIG. 296. The antheridia ♂ and pistillidia ♀ of a Moss, magnified. 297. A bursting antheridium, more magnified, with two accompanying paraphyses. 298. A Moss, Mnium cuspidatum. 299. The calyptra detached. 300. Magnified sporangium, from which the lid, or operculum, 301, has been removed; showing the peristome. 302. A portion of the annulus, magnified. 303. A portion of the outer and inner peristomes, highly magnified. 304. Simple peristome of Splachnum; the teeth united in pairs. 305. Double peristome of Hypnum; the exterior spreading. 306. Physcomitrium (Gymnostomum) pyriforme. 307. The sporangium, with 308, the calyptra, detached. 309. The lid removed from the orifice, which is destitute of peristome.

(*operculum*, Fig. 301, 309), allowing of the dispersion of the minute spores that fill it. The orifice of the sporangium is sometimes naked (Fig. 309), but is oftener more or less closed or protected by one or two rows of *teeth*, *bristles*, or processes of various shape, either combined or unconnected; these are collectively termed the *peristome* (Fig. 300, 304, 305). The teeth of the peristome are either four, or some multiple of that number (four to sixty-four). A solid axis, which often occupies the centre of the sporangium, is called the *columella*. A minute ring often found at the base of the peristome externally, is termed the *annulus* (Fig. 302). A swelling at the base of the sporangium is sometimes met with, the *apophysis*. In one genus (Andræa), the sporangium splits when ripe into four pieces, marking an evident transition towards the following family.

469. In the Hepaticæ (Hepatic Mosses, Liverworts, &c.), a degradation of the organs of vegetation is effected. In many species of Jungermannia the stem and leaves are perfect and distinct; in others, they are confounded more or less completely into a flat foliaceous expansion (*frond*), which emits roots from its lower surface, while the upper (furnished with stomata, &c.) performs the office of foliage, and gives rise to the organs of fructification; as in Fig. 312, 313, in Marchantia, the common Liverwort, &c. Usually the axis reappears in the flower-stalk (Fig. 310): yet in the floating Riccia (which may be compared with Lemna among Flowering Plants, 457, Fig. 990), there is no ascending axis at all, but the fructification is sunk in the frond itself (Fig. 313, 314). The fructification is various. The *theca*, or *sporangium*, of Jungermannia, &c., is borne on a tender cellular stalk (*seta*), arising from a foliaceous sheath (*perichæth*); and at maturity it splits open in four pieces, discharging its contents (Fig. 310). These contents are *spores*, like those of Mosses, &c., and *elaters* (Fig. 311),

which are evidently of use in the dispersion of the spores. The mode of their formation has been briefly mentioned (25). By the time the sporangium opens, the delicate walls of the tubular cell (*a*) are obliterated, and the two spiral threads uncoil elastically as they become dry, and disperse the intermixed spores. There are, besides, *antheridia*, analogous in situation and structure to those of Mosses.



310 311 312

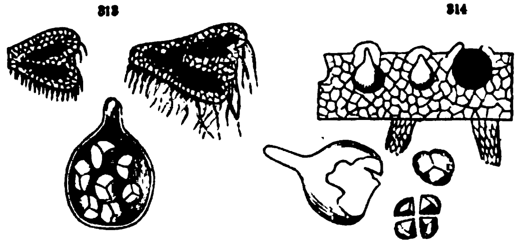
The fructification of Marchantia is analogous to this; but the sporangia are contained in involucra placed under a peltate body, in a manner quite analogous to Equisetum (464). In Riccia (Fig. 313), the thin, bottle-shaped sporangia (Fig. 315, 316), containing large quaternate spores, are immersed in the substance of the floating frond (Fig. 314); an orifice is at length formed, through which the spores (which have no elaters) are discharged.

470. The distinction into stem, root, and foliage is now entirely lost. There is no longer a regular opposition of root and stem, the indications of an axis are often obscure, and there is a tendency to evolution in flat, often in-

FIG. 310. Perichæth (with a few leaves at its base) fruit-stalk and bursting sporangium of a Jungermannia; magnified. 311. Its elaters and spores: *a*, the tube not yet broken up; *b*, the tube obliterated and the two threads elastically uncoiling; much magnified.. 312. Jungermannia Lyellii; much less than natural size; the sporangium just rising out of the perichæth.

definite expansions, or rounded masses; and which, when foliaceous, have no vestiges of stomata. This lower kind

313 314



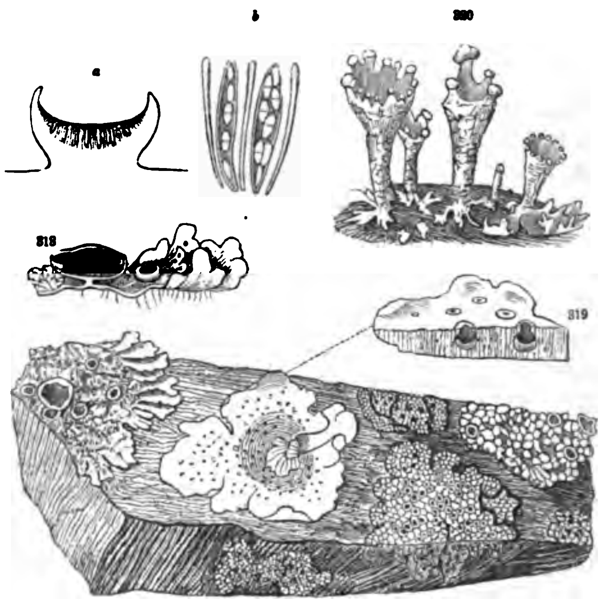
315 316

of *frond*, or bed formed by the assemblage interlacing, or more regular union of the purely cellular but often filamentous components, is in many cases termed a *thallus*. Hence these lower Flowerless Plants, of which we must now take a very cursory notice, have been called THALLOGENOUS PLANTS, or THALLOPHYTES. (The counterpart name applied to the whole series from Mosses, or even Hepaticæ, upwards, is that of CORMOPHYTES; that is, plants with a stem or axis, &c.)

471. The LICHENS form the highest grade of this lower series. They consist of flat expansions, which are rather crustaceous than foliaceous. Their structure is, as it were, anticipated in Riccia, above mentioned (Fig. 313). They are by no means aquatic, however, but grow on the ground, on the bark of trees, or on the surface of exposed rocks, to which they cling by their lower surface, often with the greatest tenacity, while by the upper they draw their nourishment directly from the air (Fig. 317). The fructification is in *cups*, or *shields* (*apothecia*, Fig. 318), resting on

FIG. 313. Riccia natans, about the natural size. 314. Magnified section through the thickness of the frond, showing the immersed sporangia; one of which has burst through and left an effete cavity. 315. Magnified vertical section of one of the sporangia with the contained spores. 316. Sporangium torn away from the base, and a quaternary group of spores, united and separated.

the surface of the thallus, or more or less immersed in its substance (Fig. 319), or else in pulverulent spots scattered over the surface. A magnified section through an apothecium (Fig. 318, *a*) brings to view a stratum of elongated sacs (*asci*), with filaments intermixed, as seen detached and highly magnified at *b*. Each *ascus*, or sac, contains a few spores, which are formed in pairs, in the fissiparous mode (21), and generally remain coherent. It should be men-



317

FIG. 317. A stone upon which several Lichens are growing, such as (passing from left to right) Parmelia conspersa, Sticta miniata, Lecidea geographica (so called from its patches resembling the outline of islands, &c., on maps), &c., &c. 318. Piece of the thallus of Parmelia conspersa, with a section through an apothecium: *a*, section of a smaller apothecium, more magnified; *b*, two asci and their contained spores, with the accompanying filaments, highly magnified. 319. Section of a piece of the thallus of Sticta miniata, showing the immersed apothecia. 320. Cladonia coccinea, bearing its fructification in rounded red masses on the edges of a raised cup.

tioned that the vegetation of some Lichens rises into a kind of axis, as in the Cladonia coccinea, which abounds on old logs, &c. (Fig. 320); or in Cladonia rangiferina, the Reindeer Moss; also in Usnea, where it forms those long, gray tufts, which hang from the boughs of old trees in our Northern forests.

472. The spores are now of the most reduced and simple kinds, mere single cells, containing granular matter, but not giving origin to more cells, or building up any structure whatever until germination. They are still more rudimentary than those formerly described, reduced to the last degree of simplicity; hence the diminutive appellation of Sporules, or Sporidia, is often applied to them.

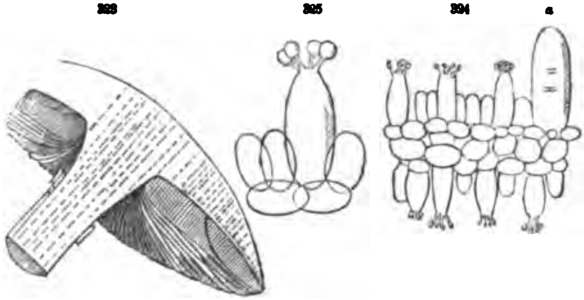
473. From the Lichens, a series of transitions conducts us by a double route, on the one hand to the Fungi, on the other to the Algæ; the two vast and multifarious groups which terminate the downward series. It is hard to say which should have precedence. Both exhibit gradations from plants of considerable complexity and large size to the minutest and simplest possible forms. The Algæ certainly rise to forms more nearly simulating the higher grades of vegetation, but as they descend to the very lowest point of the scale, we may place them last. They were also, no doubt, the earliest created tenants of our earth, and have hence been termed Protophytes: while Fungi stand in a kind of special relation to other organic things, which may now be mentioned.

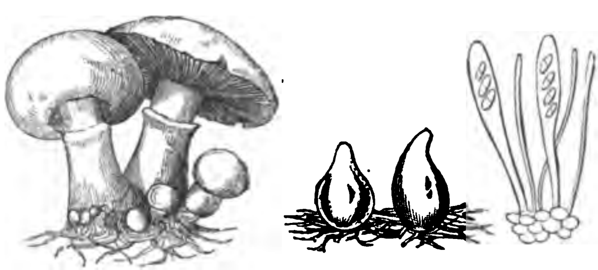
474. Fungi are parasitic (64) Flowerless Plants, either in a strict sense, as living upon and drawing their nourishment from living, though more commonly languishing, plants and animals, or else as appropriating the organized matter of dead and decaying animal and vegetable bodies. Hence they fulfil an office in the economy of creation analogous to that of the infusory animalcules. Those Fungi which pro-

duce Rust, Smut, Mildew, &c., are of the first kind: those which produce Dry-rot, &c., hold a somewhat intermediate place; and Mushrooms, Puff-balls, &c., are examples of the second. Fungi are consequently not only destitute of any thing like foliage, but also of the green matter, or chlorophylle, which appears to be essential to the formation of organic out of inorganic matter (36, 64, 222). A full account of the diversified modifications of structure that Fungi display, and of the remarkable points in their economy, would require a volume. We will notice three sorts only, which may represent the highest, and nearly the lowest, forms of this vast order or class of plants. They all begin (in germination or by offsets) with the production of copious filamentous threads, or series of attenuated cells, appearing like the roots of the fungus that arises from them (Fig. 320, 322, 326), and to a certain extent performing the functions of roots: this is called the *mycelium*, and is the true vegetation of Fungi. The subsequent developments properly belong to the fructification, or are analogous to tubers, rhizomas, &c. In one part of the order, the masses that arise, of various definite shapes, and often attaining a large size, contain in their interior a multitude of *asci* (Fig. 321), inclosing simple or double sporules, just as in Lichens (471). The esculent Morel has this kind of fructification; as well as the less conspicuous Sphæria (Fig. 320), which is in other respects of a lower grade. The Agarics, like the Edible Mushroom (Fig. 322), present a different type. Rounded tubercles appear on the mycelium; some of these rapidly enlarge, burst an outer covering which is left at the base (the *volva*, or *wrapper*), and protrude a thick stalk (*stipes*), bearing at its summit a rounded body that soon expands into the *pileus*, or *cap*. The *lamellæ*, or *gills* (*hymenium*), that occupy its lower surface, consist of parallel plates (Fig. 323), which bear naked sporules

over their whole surface. A careful inspection with the microscope shows that these sporules are grouped in fours; and the view of a section of one of the gills shows their true origin (Fig. 324). Certain of the cells (*basidia*), one of which is shown more magnified at Fig. 325, produce four small cells at their free summit, apparently in a gemmiparous manner (21): these are the *sporules*. It is maintained that the larger intermingled cells, (of which one is shown at Fig. 324, *a*,) filled with an attenuated form of matter, are the analogues of stamens.

323 325 324 a





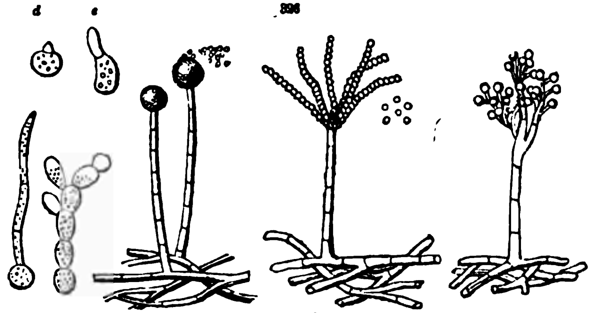
322 320 321

FIG. 320. Sphæria rosella. 321. Asci from its interior, containing sporules, highly magnified.

FIG. 322. Agaricus campestris, the Edible Mushroom, in its various stages. 323. Section through the pileus, to display the gills. 324. A small piece of a slice through the thickness of one of the gills, magnified; showing the spores borne on the summit of salient cells of both surfaces. 325. One of the sporule-bearing cells, with a little of the subjacent tissue, more magnified.

475. The lowest Fungi produce from their mycelium only simple or branching series of cells (Fig. 326). And hence their growth is simply conformable to the laws which govern the production and growth of cellular tissue. The mycelium itself either ramifies through decaying organized matter, as the Moulds, &c.; or else, like the Blight and Rust in grain, and the *Muscardine* so destructive to silk-worms, it attacks and spreads throughout living tissues, often producing great havoc before its fructification is revealed at the surface. Sometimes the last. cells of the stalks swell into a vesicle, in which the minute sporules are formed; as in Fig. 326, *a*. Sometimes the branching stalks bear single sporules, like a bunch of grapes, Fig. 326, *c*. Again, they bear long series of cells, or sporules, in rows, like the beads of a necklace (Fig. 326, *b*), which, falling in pieces, are the rudiments of new plants.

326



476. We must here intercalate the tribe, or order, of which Chara (Fig. 327) is the representative. These few aquatic plants have all the simplicity of the lower Algæ in their cellular structure, being composed of simple tubular

FIG. 326. *a*, Mucor, a common Mould: *b*, Penicillum glaucum, a kind of Mould, or Mildew: *c*, Botrytis bassiana, the parasitic fungus, which, under the name of Muscardine, attacks and destroys silk-worms.

FIG. 326, *d*–*g*. Different stages in the development of the infusory Alga (or Fungus of some writers) which abounds in fluids that are undergoing vinous fermentation.

cells placed end to end, and often with a set of smaller tubes applied to the surface of the main one (*b*, *c*). Hence they have been placed among Algæ, from which their fructification is perhaps not essentially diverse. Meanwhile their verticillate branches, and some other circumstances, show an analogy with the Equisetum tribe. They are, of all plants, those in which the rotary movement of the contents of the cells called *Cyclosis*, may be most readily observed.

477. The vast order, or rather class, of ALGÆ consists of aquatic plants; for the most part strictly so, but some grow in humid terrestrial situations. The highest forms are the proper Seaweeds (*Wrack*, *Tang*, *Dulse*, *Tangle*, &c.); "some of which have stems exceeding in length (although not in diameter) the trunks of the tallest forest-trees, while others have leaves (*fronds*) that rival in expansion those of the Palm." "Others again are so minute as to be wholly invisible, except in masses, to the naked eye, and require the highest powers of our microscopes to ascertain their form and structure." Some have the distinction of stems and fronds; others show simple or branching solid stems only; and others flat foliaceous expansions alone, either green, olive, or red in hue. From these we descend by

FIG. 327. Branch of the common Chara, nearly the natural size: *b*, a portion magnified, showing the lateral tubes inclosing a large central one (a portion more magnified at *c*); also a spore, invested by a set of tubes twisted spirally around it; and with an *antheridium* borne at its base. The contents of the latter are, in some unexplained mode, absorbed by the sporular body.

successive gradations to simple or branching series of cells placed end to end, such as the green Confervas of our pools, and many marine forms: we meet with such congeries of cells capable of spontaneous disarticulation, each joint of which becomes a new plant, so that the organs of vegetation and of fructification become at length perfectly identical, both reduced to mere cells; and finally, as the last and lowest term of possible vegetation, we have the plant reduced to a single cell, containing granular matter which gives rise to new ones, each of which at the maturity and destruction of the mother cell becomes an independent minimum plant, and repeats in turn the same process.

478. The fructification of Algæ exhibits four principal varieties. In the great division of olive-brown or olive-green proper Seaweeds, the fructification forms tubercles immersed in the tissue of the summit of the branches of the frond (Fig. 328, *a*, *b*), which are filled with a mass of simple spores with filaments intermixed (*c*), invested by a proper membranous coat, and finally escaping from the frond by a minute orifice. The beautiful red-colored Seaweeds exhibit two kinds of spores; one large, simple, superficial, and resembling those above described, except that they have no proper integument; these are thought to be analogous to bulblets; the others, dispersed through the interior of the frond, are formed four together in a mother cell, much as in the higher Flowerless Plants. The third kind is found in certain fresh-water species, which consist of single series of tubular cells placed end to end, so as to form long tubes divided by cross partitions, the cells containing a green matter like chlorophylle (36). At a certain period, two of these tubes lying in proximity, a lateral swelling appears upon several of the cells, and meets with a similar projection from the corresponding cell of the adjacent tube; the two unite; and the intervening

walls are obliterated so as to establish a free communication between the two cells. The green contents then pass from the one to the other (indifferently), the contents of the two cells unite into one mass, and by the combination form the the spore. This curious mode is shown in a common Zyg-

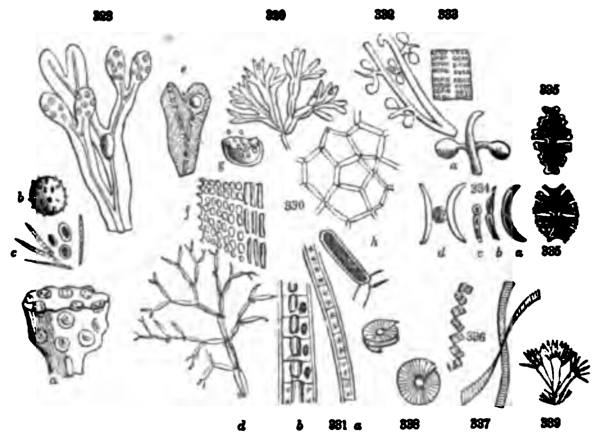
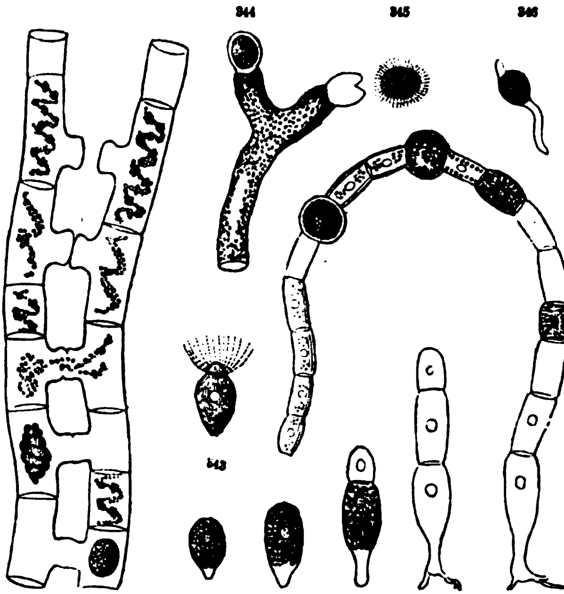


FIG. 328. Summit of the frond of Fucus vesiculosus: *a*, section of one of the receptacles; *b*, one of the contained globules; *c*, spores and jointed filaments of which the globules are composed. 329. Delesseria Le Prieurii: *d*, the sterile plant; *e*, magnified portion of the fertile frond; *f*, portion of the same more magnified, showing its tissue from the mid-rib to the margin; *g*, theca, opened, with the spores. 330. Portion of the network of Hydrodyction utriculatum; *h*, a magnified joint, filled with the green matter which developes into a new plant. 331, *a*. Single filament of Tyndaridea cruciata, showing the star-shaped bodies, enveloped in mucus: *b*, two filaments of the same united side by side. 332. Vaucheria geminata, in fruit: *a*, Vesicular receptacles, enlarged. — The remaining figures represent some of the ambiguous Diatomaceæ. 333. Gonium glaucum, of Ehrenberg, who thinks it a congeries of animalcules; while Meyen has described it as an Alga. 334. Closterium Lunula; usually filled with floating green globules: *a*, the perfect vegetable; *b*, the same, separating into two by spontaneous division; *c*, an individual resulting from this spontaneous division, developing a second; *d*, two individuals conjugately united; the green matter all collected in the uniting globule. 335. Euastrum Pecten, and E. Crux-Melitensis. 336. A Diatoma, breaking up into separate individuals. 337. A Fragillaria. 338. Meridion circulare, front and side views. 339. Echinella flabellata; perhaps a group of animalcules.

nema at Fig. 340, where the whole process may be traced. In the fourth mode, one which occurs in the remaining fresh-



water Algæ, or Confervas, and in some marine species, a condensation of the green matter of a single cell gives rise to one or several spores. Conferva vesicata (Fig. 341–343)

FIG. 340. Magnified view of two conjugating filaments of Zygnema, showing all the stages of the process by which the green contents of two cells from different filaments are combined to form a spore.

FIG. 341, *a*, *b*, *c*. Successive steps in the germination of Conferva vesicata. 342. The plant developed into a series of cells, four of which display the successive steps in the formation of a spore. 343. The locomotive spore with its vibratile cilia (copied from Thuret). When its movement ceases, and it begins to germinate, it appears as in 341.

FIG. 344. Fruiting end of a plant of Vaucheria geminata (after Thuret); one of the branches still containing its spore. 345. Moving spore just escaped from the apex of the other branch; the ciliary apparatus seen over the whole surface. 346. Spore in germination.

affords one example, and Vaucheria (Fig. 344–346) another. But their most remarkable peculiarity is still to be mentioned. The spores of this kind exhibit brisk spontaneous movements, both in the mother cell and especially after they escape from it, which continue for some hours, and until they are about to germinate; movements which may be enfeebled or arrested by the application of a weak solution of opium, and which are found to be produced by means of a ciliary apparatus, strikingly like that of the lowest infusory animalcules. In Conferva the tuft of vibratory bristles occupies one end of the spore (Fig. 343), presenting an analogy to the animalcules of the class Rotiferæ. In Vaucheria, this apparatus covers the whole surface of the spore (Fig. 345), which therefore resembles a polygastric animalcule!

479. The whole economy of the Diatomaceæ (Fig. 334–338), one of the lowest groups of Algæ, if it do not form a separate order, also presents peculiarities of the most striking resemblance to those of animals, so that they are claimed at the same time by the zoölogist as well as the botanist. We see not how they are to be separated from the vegetable kingdom, especially if they evolve oxygen gas, as they are said to do. But, wherever the line be drawn, in reaching the borders of the vegetable kingdom, we make the closest possible approach to the lowest confines of the animal creation!

480. In speaking as we have all along done of the lower forms of plants as simplifications of the fully realized *type* of vegetation, we trust that we shall not be understood to mean that they are *imperfect* plants in any other sense than this, or to maintain that they are in any respect to be considered as higher plants in an imperfectly developed state, or that the higher forms really arise from the further development of the lower species themselves.

CHAPTER XIII.

OF SPONTANEOUS MOVEMENTS, ETC., IN FLOWERING PLANTS.

481. THE spontaneous movements that many of the lowest Flowerless plants, or their spores, so freely execute (478) tend to destroy one of the characteristics that have been employed to contradistinguish the vegetable from the animal kingdom; namely, that which attributes sensation and voluntary motion to the latter, and denies it to the former. Not only do many, if not all plants exhibit *sensitiveness* to external agents, and more or less decided consequent movements, but, on the other hand, *locomotion* is by no means an universal characteristic of animals. Many of the latter are *fixed*, during the whole or the greater part of their existence, as absolutely as plants in general are; while the movements of particular parts which they do effect, are scarcely more decided or extensive than what is sometimes observed in plants. We can no longer refer these ambiguous lower forms to the animal kingdom on the ground of their spontaneous movements; and still less adopt the paradox maintained by some learned German physiologists, that the spores or seeds of the Conferva tribe, &c., actually enjoy a transitory animal existence, but soon in germination revert again to the vegetable state. It is important to inquire, therefore, whether the higher grades of plants do not exhibit, in some degree, similar or analogous vital manifestations.

482. One class of such manifestations is found in the special directions which the organs of plants assume; such as the invariable descent of the root in germination, the as invariable rising of the stem upwards into the light and air,

and the turning of branches and the upper surface of leaves towards the light (43, 137, 143). Although these movements are excited or brought about by common physical agents (just as analogous kinds of movements are in animals), yet nearly all of them are inexplicable upon mechanical principles. Some of them, at least, are spontaneous motions of the plant or organ itself, due to some inherent power, which is merely put in action by light, attraction, or other external influences.

483. The external agencies concerned in the descent of the root and the rise of the stem seem chiefly to be, 1st, the attraction of the earth acting upon the root; and 2d, the influence of light upon the stem. The influence of gravitation, or of a similar force, was proved by the celebrated experiment of Mr. Knight; who caused the seeds of the Bean to germinate in a quantity of Moss fastened to the circumference of a wheel, which was made to revolve vertically at a rapid rate; where the seeds were subjected to the centrifugal force alone, acting like that of gravitation, but in the opposite direction. On examination, after some days, the young root and stem were found to have taken the direction of the axis of rotation; the former being turned towards the circumference, and the latter towards the centre of the wheel. The same result took place when the wheel was made to revolve horizontally with considerable rapidity; but when the velocity was moderate, the roots were directed obliquely downwards and outwards, and the stems obliquely upwards and inwards, in obedience both to the centrifugal force and the power of gravitation, acting at right angles to each other. That light is the chief cause of the upward direction of the stem, while it is avoided by the roots, appears from a recent experiment by Professor Schultz, of Berlin; who reversed the natural condition, by causing seeds to germinate in Moss, so arranged that the only light they could receive was

reflected from a mirror, which threw the solar rays upon them directly from below; in which case he found that their roots were sent upward into the moss, and their stems downward towards the light. The Mistletoe obeys the attraction of the trunk or branch upon which it is parasitic (64), just as ordinary plants obey the attraction of the earth; its roots penetrating towards the centre, while the stems grow perpendicular to the surface of the branch, and are therefore placed in various positions as respects the earth. When the germinating seeds of the Mistletoe were glued to the surface of a cannon-ball, all the radicles were found to be directed toward its centre. A well-devised experiment made by Dutrochet goes to show, that the direction of the radicle to the adjacent body (and consequently of the germinating root generally towards the earth's centre) is not the result of the immediate attraction of the adjacent body, or of the earth, but is a spontaneous movement due to some internal, vital cause, put in action by the exterior influence. He mounted the seed of a Mistletoe upon one extremity of a very delicately balanced needle, which would turn with the slightest force, and placed it at the distance of half a line from the surface of a large cannon-ball. In germination the radicle directed its point to the ball, and soon came into contact with the surface; but that end of the needle had not moved in the slightest degree towards the ball, as it would have done from a mere exterior attraction.

484. When the stem has emerged from the earth, it tends to expose itself as much as possible to the light, the growing parts always turning towards the side most strongly illuminated; as is observed when a plant is placed in an apartment lighted from a single aperture. This is mechanically accounted for by De Candolle, on the supposition that, as the side upon which the light strikes will fix most carbon by the decomposition of carbonic acid, so its tissue will be-

come more solid than the shady side, and therefore elongate less rapidly; and the stem or branch will consequently bend towards the light. But when the light is equally diffused around a plant, the decomposition of carbonic acid will take place uniformly on all sides, and the perpendicular direction naturally be maintained. The same law would regulate the disposition of branches, which are invariably so arranged as to have the greatest possible exposure to the light; the uppermost branches of a tree growing nearly erect, those beneath them extending more horizontally until they reach beyond their shade, when they curve upwards (unless too slender to support their own weight, as in the Weeping Willow), and the lower are still more divergent, or even turned downwards, when the foliage is dense. The divergence of the branchlets takes place in the same manner. This effect, however, is confined to the green parts of plants, which alone decompose carbonic acid under the influence of light (222). The direction of old branches, where the surface has lost its green color, is no longer affected in this way; and those which creep under ground beyond its influence (85), and have the white color and much the appearance of roots, show little upward tendency so long as they remain in this situation; but whenever their extremities are exposed to the light, they first acquire a green hue by the formation of chlorophylle, and then assume a vertical direction.

485. In leaves, it is the deeper colored surface that is always presented to the light. But the turning of this surface towards the light cannot be explained as a mere physical effect of that agent upon the leaf. A leaf cut from its stalk, attached to a hair, and plunged by a bit of lead in a glass vessel filled with water, when exposed in a window will perform its functions of digestion (223) as well as ever, but it will not turn its upper surface towards the light. The

light can produce this motion, only by its influence on some power inherent in the vegetable itself.

486. Still less will purely physical explanations account for the reaching forth of tendrils, or the twining of those stems which act like tendrils; in which the green parts turn *from* the light instead of *towards* it. We pass to more obvious cases of spontaneous movements.

487. When the stimulus of light is removed, the leaves of many plants droop, or are folded together, and their flowers often close, as if in repose; phenomena which Linnæus termed the *sleep of plants*. The leaflets of compound leaves, in such cases, are variously disposed in different plants, while the nocturnal position is uniform in each species, showing that the phenomenon is purely vital. De Candolle found that most plants could be made to acknowledge an artificial day and night, by keeping them in darkness during the day, and by illuminating them with candles at night. The sensibility to light resides in the petiole, and not in the blade of the leaf: for these movements are similarly executed, when a great part of the latter is cut off.*

* The flowers of different species are variously affected by the light. Many expand their blossoms in the morning and close them towards evening, never to be opened again, as those of Cistus, and many Portulaceous plants; while others, like the Crocus, close when the sun is withdrawn, but expand again the following morning. On the other hand, the Evening Primrose, Silene noctiflora, &c., unfold their petals at twilight, and close at sunrise. The White Water-Lily (Nymphæa) expands in the full light of day, but uniformly closes near the middle of the afternoon, and is withdrawn beneath the surface of the water. The Morning Glory opens at the dawn; the Lettuce and most Cichoraceous plants a few hours later; the Mirabilis, or Four-o'clock plant, nearly at that hour in the afternoon, &c. Berthellot mentions

488. Many plants exhibit a still greater degree of excitability; their leaves being sensitive to the touch of external objects, as well as to light. The Sensitive Plant (Mimosa pudica) is a familiar instance of the kind: but it scarcely exceeds the Schrankia of the Southern States, where the leaflets rapidly fold up, as if in a state of sleep, when brushed with the hand. But the most remarkable instance of the kind is observed in another native of the United States, the Dionæa muscipula, or Venus's Fly-trap (Fig. 437); where the touch, even of an insect alighting upon the upper surface of the outspread lamina, causes its sides suddenly to come together with considerable force, the strong bristles of the marginal fringe crossing each other like the teeth of a steel-trap, so as to retain the intruder; whose struggles only increase the pressure which this ani mated trap exerts.

489. The stamens of the common Barberry are so excitable, that they approach the pistil with a sudden jerk, when touched with a point near the base: the end of this motion seems to be the dislodgment of the pollen and its projection upon the stigma. In a species of Stylidium, not uncommon in cultivation, the column, consisting of the

---

an Acacia at Teneriffe, whose leaflets regularly close at sunset and unfold at sunrise, while its flowers close at sunrise and unfold at sunset. The odors of flowers, also, are sometimes given off continually, as in the Orange and the Violet, or else they nearly lose their fragrance during the heat of mid-day, as in most cases; while others, such as Pelargoniun tristis, Hesperis tristis, and most dingy flowers, which are almost scentless during the day, exhale a powerful fragrance at night. The Night-flowering Cereus grandiflorus emits its powerful fragrance at intervals; sudden emanations of odor being given off about every quarter of an hour, during the brief period of the expansion of the flower.

united stamens and styles, is bent over one side of the corolla; but if slightly irritated, it instantly springs over to the opposite side of the flower. Some other movements, which have been likened to these, are entirely mechanical in their nature; as that of Kalmia, or Sheep Laurel, where the ten anthers are in the bud received into as many pouches of the monopetalous corolla, and being retained by a glutinous exudation, are carried outwards and downwards when the corolla expands. In this way the slender filaments are strongly recurved, like so many springs, until the anthers open, and the pollen absorbs the glutinous matter that confines them; when they fly upwards elastically, throwing the pollen in the direction of the stigma. The bursting of the fruit of the Squirting Cucumber (Momordica Elaterium), and the elastic dehiscence of the Balsam, or Touch-me-not (Impatiens), are also due to mechanical or endosmometric (146) causes; and therefore are not to be adduced as instances of vegetable irritability.

490. An instance of spontaneous and continued motion, of the most remarkable kind, is furnished by the trifoliolate leaves of Desmodium gyrans, an East Indian Leguminous plant. The terminal leaflet does not move, except to sleep; but the lateral ones are continually rising and falling, both day and night, by a succession of little jerks, like the second-hand of a time-keeper; the one rising while the other falls. Exposure to cold, or cold water poured upon the plant, stops the motion, which is immediately renewed by warmth. In several tropical Orchideous Plants, and especially in a species of Megaclinium cultivated in Europe, one of the petals executes similar and perfectly spontaneous automatic movements.

491. These phenomena depend upon physical conditions; but the physical forces or agents are but means of execution. When we consider that this excitability is often trans-

mitted, as if by a sort of sympathy, from one part to another; that it is soon exhausted by repeated excitation (as is certainly the case in Dionæa, the Sensitive Plant, &c.) and is only renewed after a period of repose; that all plants require a season of repose (249); that they evolve heat under special circumstances (245); that, as if by a kind of instinct, the various organs of the vegetable assume the positions or the directions most favorable to the free exercise of their functions and the supply of their wants, to this end surmounting intervening obstacles; when we consider in this connection those still more striking cases of spontaneous motion that the lower Algæ exhibit (478), and that all these motions are arrested by narcotics, or other poisons, — the narcotic and acrid poisons even producing effects upon vegetables respectively analogous to their different effects upon the animal economy, — we can hardly avoid attributing to plants a *sensibility* not different in nature, so far as we know, from that of the lower animals. Probably the *vitality* is essentially the same in the two kingdoms; and that to this, faculties and attributes are superadded in the lower animals, some of which are here and there not indistinctly foreshadowed in plants.

492. Finally, if called upon to define a plant, or draw the line between the animal and the vegetable kingdoms, we can only say; 1. That plants alone, under the solar influence, create organic matter from inorganic materials, and alone live, or are capable of living, by direct aggression upon the mineral world (223, 235). Consequently, they alone decompose carbonic acid, and render free oxygen gas to the atmosphere (224): the action of animals upon the air is uniformly and continually the reverse. 2. In their structure, a plant may be reduced to a single simple vesicle of cellular tissue (477), containing chlorophylle, or its equivalent. But a developed animal of the very lowest

grade has a more complex structure: from the necessity of the case it possesses a mouth and a stomach. Indeed, we have reason to believe that the polygastric animalcules are considerably complicated in structure. 3. As to chemical composition, the tissue of plants, or the material of which the cells are constructed, is a neutral ternary product (225), composed of carbon, hydrogen, and oxygen. Although the plant contains and produces the quaternary organic products, these do not enter into the composition of its fabric. The animal tissue, on the contrary, is directly composed of neutral quaternary products, consisting of carbon, hydrogen, oxygen, and nitrogen. Although these distinctions are, in all probability, absolute, yet it is often difficult, and frequently, perhaps, impossible, to apply them to the actual discrimination of the lower plants from the lower animals.

PART II.

SYSTEMATIC BOTANY.

---

493. We must now contemplate the vegetable creation from a different point of view. In studying the structure and physiology of plants, we have been struck with the countless varieties of forms which they present, the almost infinite number of particular modes or forms in which the general plan of vegetation has been worked out, as it were, in detail. The vegetable kingdom, that is, vegetation taken as a great whole, presents to our view an immense number of different kinds or sorts of plants, more or less resembling each other, more or less nearly related to each other. It is the object of Systematic Botany to consider them in respect to these resemblances and differences, — to contemplate the relations which the individual members of the great whole sustain to each other (5, 6). In this view, the botanist classifies them, so as to exhibit their relationships, or points of resemblance, arranges them in an orderly manner, designates them by proper names, and distinguishes them by clear and precise descriptions; so that the name and place in the system, the known properties, and the whole history of any given plant may be readily and surely obtained by the learner.

CHAPTER I.

OF CLASSIFICATION AND ITS PRINCIPLES.

494. The vegetables with which the earth is adorned are presented to our view as Individuals only, more or less resembling, or differing from, each other. Among these, some are so essentially alike, that we involuntarily apply to them the same name. A field of Wheat is filled with similar individuals, which we can *separate*, but cannot *distinguish*. Or, although it be possible to distinguish separate individuals, from any peculiarity of size, &c., we still inevitably associate them, as being much more like each other than like any surrounding forms, — so like, that we view the difference as an accidental circumstance. Furthermore, the Wheat *tillers*, that is, branches from the ground, and shoots forth a number of stalks from the same root, — stalks which are separable, or separate spontaneously from the primary one. So, also, the branches of trees, which may grow indefinitely as a part of an original tree (72), become, when detached and planted by themselves in the soil, independent but perfectly similar individuals (128 – 131). Probably all the Weeping Willows, or Lombardy Poplars, of this country have sprung in this way from a single shoot. The grain of wheat, also, will reproduce similar individuals, and none other.

495. Now upon such universal and inevitable conceptions as these rests the idea of species. We assemble, under this name, those individuals which we observe or judge to have arisen from one parent stock, or which, although met with widely dissociated, resemble each other so closely that we infer them to have had a common parentage. A Species,

or particular sort, therefore, embraces all those individuals which, slightly differing perhaps in size, color, or such unimportant respects, resemble each other more nearly than they resemble any other plants, so that we infer them to have sprung from a common original stock, and which preserve their characters unchanged when propagated by seed. All classification and system in natural history rest upon the fundamental idea of the original creation of certain forms, which have naturally been perpetuated unchanged, or with such changes only as we may conceive or prove to have arisen from varying physical influences, accidental circumstances, or from cultivation.

496. This fraternal resemblance, or specific identity, however, is not incompatible with individual peculiarity. If two seeds from the same pod are sown in different soils, and submitted to different conditions as respects heat, light, and moisture, the plants that spring from them will show marks of this different treatment in their appearance. Such differences are continually arising in the natural course ot things. To produce and increase, and by artificial management to perpetuate, differences of this sort, forms an important part of the art of cultivation. These minor deviations, not incompatible with a common origin, constitute VARIETIES. Whenever the conditions that give rise to varieties are carried to excess, these individuals fail to fructify, or perish. When the conditions vary less widely from those most propitious to the constitution of the particular species, a few years or a few generations suffice to bring the variety back to the original form. In either case, the variation is transient. It must either return to the common character of the species, or perish. A certain flexibility is allowable; but accidental and individual variations generally disappear with the causes which originate them, or are destroyed by the continued operation of those causes.

497. To this there is one class of exceptions, which, however, have no marked or permanent existence in uncontrolled nature. The habit, once established, sometimes outlasts the cause, and continues throughout the life of the individual. The new buds and branches partake of the peculiarity, and the variety may consequently be perpetuated by cuttings, grafts, &c.; as is the case with our Apples, Pears, &c. But this tendency does not inhere in the seed.

498. There is still another and more strongly marked kind of variety, — though unknown, perhaps, in a perfectly wild state, — in which the characteristics are transmissible by seed. Particular varieties of Peas, Radishes, Lettuce, &c., are thus perpetuated in our gardens; and in agriculture, various sorts of grain have thus been preserved from time immemorial. They have received the name of *Races*. It is not known how they originate. They start up, as it were, accidentally, from time to time, in cultivated plants. The cultivator selects the most promising sorts, or "sports," for preservation, leaving the others to their fate. By peculiar care he developes and strengthens the tendency to become hereditary, and renders it paramount (under the circumstances and conditions of cultivation) to that stronger natural tendency to reversion to the primitive type, and so secures his particular end. The races of Corn, Wheat, &c., which now preserve their character unchanged, have become fixed by centuries of domestication. Even these, at times, manifest an unequivocal disposition to return to their aboriginal state. Were cultivation to cease, they would all speedily disappear; the greater part, perhaps, would perish outright; the remainder would revert, in a few generations of spontaneous growth, to the form of the primitive stock.

499. A still different class of variations are artificially, and sometimes naturally produced, by fertilizing the ovary

of one plant with the pollen of a nearly allied species; from which arise what are called *Cross-breeds*, or *Hybrids*. Crosses between different species, however, are almost always incapable of producing fertile seed, and therefore are not perpetuated in nature: those between distinct varieties of the same species are usually fertile, and give rise to new sets of varieties (also termed *Races*), in which the particular qualities of their immediate parents are variously modified or blended; but which, by a continuation of the same influences, revert to one or the other parent stock.

500. If but a moderate number of species were known, no system of generalizing, or arranging them in groups, would be necessary for ordinary purposes; though a consideration of the various degrees of resemblance between different species could not fail to suggest some form of generalization, like that which the great number of species early rendered imperatively necessary. The first step in proper classification, the bringing together of species in kinds, according as they are seen to resemble each other, is almost as natural and inevitable an operation of the mind, as is the idea of species involuntarily deduced from the assemblage of like individuals. The generic association, however, implies only resemblance, or similarity of kind, not identity of origin.

501. A GENUS, therefore, is an assemblage of nearly related species, agreeing with one another in general structure and appearance more closely than they accord with any different species. Thus, the wild Swamp Rose, the Sweet-Brier, the Dog Rose, French Rose, Cinnamon Rose, and others, constitute the universally recognized genus Rosa; the various species of Raspberry and Blackberry compose the genus Rubus; the Apple, Pear, &c., the genus called by botanists Pyrus: so the different Oaks, Willows, Poplars, Birches, &c., form as many separate genera. The lan-

guages of the most barbarous people show that they have formed such associations. Naturalists merely give to these generalizations a greater degree of precision, and endeavour to indicate what the points of common agreement are. A single species, also, may be deemed to constitute a genus, when its peculiarities are equivalent in degree to those which characterize other genera, — a case which often occurs. If only one species of Oak were known, the Oak genus would have been as explicitly recognized as it is now that the species amount to two hundred; it would have been equally distinguished by its acorn and cup from the Chestnut, Beech, Hazel, &c. A genus, then, is a group of species which present the same particular plan, and whose mutual resemblance is greater than that of any one of them to any other plants.

502. When two or more species of a genus resemble each other in particular points more nearly than they do the other species, intermediate sections are often recognized; which, when well marked by characters of considerable importance, receive the title of SUBGENERA.

503. If the genera were few, there would be little necessity for higher generalizations; although one could not but remark that the Oaks, Chestnuts, Beeches, and Hazels have a strong common resemblance, or family likeness; and that they are more unlike Birches and Alders, or Walnuts and Hickories; that they are still more unlike Maples or Ashes, and have yet fewer points in common with Pines and Firs. But, since the 100,000 species of known plants are distributed among about 7,000 genera, it is necessary to consider these family resemblances, for the purpose of grouping the genera into still higher, and therefore fewer groups; just as genera are formed by the reunion of related species. The groups thus established are termed FAMILIES, or ORDERS. Thus, the Rose, the Raspberry and Black-

berry, with the Strawberry, the Apple, the Thorn, the Plum and Cherry, &c., all agreeing in their general plan of structure, are brought together into one order or family, and termed *Rosaceæ;* that is, Rosaceous, or Rose-like plants.

504. But, viewed subordinately, the Plum and Cherry are evidently more nearly akin than the Cherry and Apple, &c.; and so the Raspberry, Blackberry, and Strawberry on one hand, and the Apple and Thorn on the other, exhibit a closer relationship than that which connects them all in one common group. Hence they are respectively distinguished into groups of a rank intermediate between genera and orders, which are variously termed SUBORDERS, or TRIBES.*

505. CLASSES are groups of orders, associated in a similar manner from some higher point of view. SUBCLASSES bear the same relation to classes that suborders do to orders.

506. By this regular subordination of groups, the various degrees of relationship among plants may be expressed;

---

* When the groups which an order embraces are distinguished by characters of nearly equal value with those commonly employed for orders themselves, they are termed SUBORDERS. Thus, the Plum, Cherry, Apricot, Peach, &c., form one suborder of Rosaceæ; the Raspberry, Blackberry, Strawberry, Cinquefoil, with the Rose and other genera, constitute another suborder; and the Apple, the Quince, Thorn, &c., a third. The name of TRIBE is applied to groups comprised in a suborder (thus the Rose constitutes a separate tribe from the Raspberry, Strawberry, &c.), or to the primary divisions of an order, when they are not founded on characters of high importance. In a loose and popular sense, the name of tribe is frequently used as if synonymous with that of order or family. Thus we say, the Pea tribe, the Fir tribe, the Violet tribe, &c., merely as a simpler expression for "The family of which the Pea, &c., is a representative."

and upon this Systematic Botany essentially depends. Only four of these divisions are universally employed, namely, Classes, Orders, Genera, and Species: these are common to all methods of classification, and are always arranged in the same sequence. But a more elaborate analysis is often requisite, on account of the large number of objects to be arranged, and the various degrees of affinity to be expressed; when the additional members, and if need be several others, are introduced; as in the following descending series:

Classes,
Subclasses,
Orders,
Suborders,
Tribes,
Subtribes,
Genera,
Subgenera,
Species.

507. An enumeration of the distinguishing marks, or points of difference between one class or order, &c., and the others, is termed its *character*. The characters of the classes, and other primary divisions, embrace only those important points of structure upon which they are constituted: the *ordinal character* describes the general structure of the included plants, especially of their flowers and fruit: the *generic character* points out the particular modifications of the ordinal structure in a given genus; and the *specific character*, those less important modifications of form, relative size, color, &c., which serve to distinguish kindred species. A complete system of Botany will therefore comprise a methodical distribution of plants according to their organization, with their characters arranged in proper subordination; so that the investigation of a particular species will bring to view, not only its name (which separately

considered is of little importance), but also its floral structure, affinities, and whole natural history.

508. Such a system must of course be *natural;* that is, the groups, of whatever rank, must be composed of plants more closely related to each other than to any different groups, and so arranged that each shall stand, as far as practicable, next to those which it most nearly resembles in structure. These conditions are so far fulfilled by the Natural System (which, sketched by the master-hand of Jussieu, and augmented by succeeding botanists, is now generally adopted), as to render it on the whole far the readiest, as well as the only philosophical and satisfactory, mode of acquiring any considerable amount of botanical knowledge; notwithstanding its manifold imperfections, and peculiar difficulties.

509. But the relationships of plants, even when appreciated by botanists, could not be made available for the purpose of classification, until just views prevailed in vegetable organography and physiology, which constitute the very foundation of Systematic Botany, but which have only recently been placed upon a philosophical basis. Hence the immortal Linnæus, finding it impossible in his day to characterize the natural groups which his practised eye detected, proposed, as a temporary substitute, the elegant artificial scheme which bears his name. As this system is identified with the history of the science, which in its time it so greatly promoted, and as most systematic works have until recently been arranged upon its plan, it is still necessary for the student to understand it. Fortunately, its principles are so simple that a brief space will amply suffice for its explanation.

CHAPTER II.

OF THE ARTIFICIAL SYSTEM OF LINNÆUS.

510. It must be kept in mind, that an artificial scheme does not attempt to fulfil all the conditions of natural history classification. Its principal object is to furnish an easy mode of ascertaining the names of plants; their relationships being only so far expressed as the plan of the scheme admits. All higher considerations are of course sacrificed to facility. In the Linnæan scheme, the species of a genus are always kept together, whether or not they all accord with the class or order under which they are placed. Its lower divisions, therefore, namely, the genera and species, are the same as in a natural system. But the genera are arranged in artificial classes and orders, founded on some single technical character, and have no necessary agreement in any other respect. Hence they may be likened to words alphabetically arranged in a dictionary, where those which stand next each other have, it may be, nothing in common beyond the initial letter.

511. The classes and orders are entirely founded upon the number, situation, and connection of the stamens and pistils; the office and importance of which Linnæus had just set in a clear light.

512. The classes, twenty-four in number, are founded upon modifications of the stamens, and have names of Greek derivation expressive of their character. The first eleven comprise all plants with perfect flowers, and a definite number of equal and unconnected stamens; they are distinguished by the absolute number of these organs, and are designated by names compounded of Greek numerals and

the word *andria* (from ἀνήρ), which is used metaphorically for stamen; as follows.

Class 1. MONANDRIA includes all such plants with one stamen to the flower.
2. DIANDRIA, those with two stamens.
3. TRIANDRIA, with three stamens.
4. TETRANDRIA, with four stamens.
5. PENTANDRIA, with five stamens.
6. HEXANDRIA, with six stamens.
7. HEPTANDRIA, with seven stamens.
8. OCTANDRIA, with eight stamens.
9. ENNEANDRIA, with nine stamens.
10. DECANDRIA, with ten stamens.
11. DODECANDRIA, with twelve to nineteen stamens.

The two succeeding classes include plants with perfect flowers, having twenty or more unconnected stamens, which in

12. ICOSANDRIA, are inserted on the calyx (perigynous, 339); and in
13. POLYANDRIA, on the receptacle (hypogynous, 339).

Their essential characters are not designated by their names; the former merely denoting that the stamens are twenty in number; the latter, that they are numerous. The two following depend upon the relative length of the stamens, namely,

14. DIDYNAMIA, including those with two long and two short stamens (310); and
15. TETRADYNAMIA, those with four long and two short stamens (340).

Their names are Greek derivatives, signifying in the former that two stamens, and in the latter that four stamens, are most powerful. The four succeeding are founded on the connection of the stamens:

Class 16. MONADELPHIA (meaning a single fraternity), with the filaments united into a single set, tube, or column (340).

17. DIADELPHIA (two fraternities), with the filaments united in two sets or parcels (340).

18. POLYDELPHIA (many fraternities), with the filaments united in more than two sets or parcels.

19. SYNGENESIA (from Greek words signifying to grow together), with the anthers united into a ring or tube (340).

The next class, as its name denotes, is founded on the union of the stamens to the style:

20. GYNANDRIA, with the stamens and styles consolidated (304).

In the three following, the stamens and pistils are separated (306): thus,

21. MONŒCIA (one household) includes plants where the stamens and pistils are in separate flowers on the same individual.

22. DIŒCIA (two households), where they occupy separate flowers on different individuals.

23. POLYGAMIA, where the stamens and pistils are separate in some flowers and united in others, either on the same or two or three different plants.

The remaining class,

24. CRYPTOGAMIA, is said to have concealed stamens and pistils (as the name imports), and includes the Ferns, Mosses, Lichens, &c., which are now commonly termed Cryptogamous, or Flowerless plants (459).

The characters of the classes may be presented at a single view, as in the subjoined analysis:

Synoptical View of the Linnæan Artificial Classes.

Plants having	stamens and pistils manifest,	both found in the same flower,	the stamens separate from the pistils,	unconnected with each other, and	of equal length :	Stamens 1 - - - - - - - - 1. Monandria.
						" 2 - - - - - - - - 2. Diandria.
						" 3 - - - - - - - - 3. Triandria.
						" 4 - - - - - - - - 4. Tetrandria.
						" 5 - - - - - - - - 5. Pentandria.
						" 6 - - - - - - - - 6. Hexandria.
						" 7 - - - - - - - - 7. Heptandria.
						" 8 - - - - - - - - 8. Octandria.
						" 9 - - - - - - - - 9. Enneandria.
						" 10 - - - - - - - - 10. Decandria.
						" 11–19 - - - - - - - 11. Dodecandria.
						" 20 or more, adherent to the calyx 12. Icosandria.
						" 20 or more, not adherent to the calyx 13. Polyandria.
					of unequal length :	two long and two short stamens - - - - 14. Didynamia.
						four long and two short stamens - - - - 15. Tetradynamia.
				connected with each other		by their filaments in a single set - - - 16. Monadelphia.
						by their filaments in two sets - - - - 17. Diadelphia.
						by their filaments in more than two sets - - 18. Polyadelphia.
						by their anthers - - - - - - - 19. Syngenesia.
			the stamens adherent to the pistil - - - - - - - - - - -			20. Gynandria.
		in separate flowers, - - - - - - -				in the same individuals - - - - - - 21. Monœcia.
						in different individuals - - - - - - 22. Diœcia.
						some of the flowers perfect, others separated, in the same, or two or three different individuals - - - - - - - - - 23. Polygamia.
	the stamens and pistils concealed, or none - - - - - - - - - - - - - - - -					24. Cryptogamia.

513. The orders, in the first thirteen classes of the Linnæan artificial system, depend on the number of styles, or of the stigmas when the styles are wanting; and are named by Greek numerals prefixed to the word *gynia*, used metaphorically for pistil, as follows.

Order 1. MONOGYNIA embraces all plants of any of the first thirteen classes, with one style to each flower.
2. DIGYNIA, embraces those with two styles.
3. TRIGYNIA, those with three styles.
4. TETRAGYNIA, those with four styles.
5. PENTAGYNIA, those with five styles.
6. HEXAGYNIA, those with six styles.
7. HEPTAGYNIA, those with seven styles.
8. OCTOGYNIA, those with eight styles.
9. ENNEAGYNIA, those with nine styles.
10. DECAGYNIA, those with ten styles.
11. DODECAGYNIA, those with eleven or twelve styles.
12. POLYGYNIA, those with more than twelve styles.

The orders of class 14, Didynamia, are only two; namely,
1. GYMNOSPERMIA, meaning seeds naked, the achenia-like fruits having been taken for naked seeds.
2. ANGIOSPERMIA, with the seeds evidently in a seed-vessel or pericarp.

The 15th class, Tetradynamia, is also divided into two orders, which are distinguished by the mere form of the pod:
1. SILICULOSA; the fruit a silicle (427), or short pod.
2. SILIQUOSA; fruit a silique (427), or more or less elongated pod.

The orders of the 16th, 17th, 18th, 20th, 21st, and 22d classes, depend merely on the number of stamens; that is, on the characters of the first thirteen classes, whose names they likewise bear: thus,

Order 1. MONANDRIA; 2. DIANDRIA; and so on.

The orders of the 19th class, Syngenesia, are six; namely,

1. Polygamia æqualis, where the flowers are in heads (compound, 269), and all perfect.
2. Polygamia superflua, the same as the last, except that the rays, or marginal flowers of the head, are pistillate only (306).
3. Polygamia frustranea, those with the marginal flowers neutral (306, note), the others perfect.
4. Polygamia necessaria, where the marginal flowers are pistillate and fertile, and the central (those of the disk) staminate and sterile.
5. Polygamia segregata; where each flower of the head has its own proper involucre.
6. Monogamia, where solitary flowers (that is, not united into a head) have united anthers, as in Lobelia. This order was abolished by succeeding botanists, but upon insufficient grounds.

The 23d class, Polygamia, has three orders, founded on the characters of the two preceding classes; namely,

1. Monœcia, where both separated and perfect flowers are found in the same individual.
2. Diœcia, where the different flowers occupy different individuals.
3. Triœcia, where one individual bears the perfect, another the staminate, and a third the pistillate flowers.

The orders of the 24th class, Cryptogamia, are natural, and therefore indefinable by a single character. They are,

1. Filices, the Ferns.
2. Musci, the Mosses.
3. Algæ, which, as left by Linnæus, comprised the Hepaticæ, Lichens, &c., as well as the Seaweeds
4. Fungi, Mushrooms, &c.

CHAPTER III.

OF THE NATURAL SYSTEM.

514. The object proposed by the Natural System of Botany is to bring together into groups those plants which most nearly resemble each other, not in a single and perhaps unimportant point (as in an artificial classification), but in all essential particulars; and to combine the subordinate groups into larger natural assemblages, and these into still more comprehensive divisions, so as to embrace the whole vegetable kingdom in a methodical arrangement. All the characters which plants present, that is, all the points of agreement or difference, are employed in their classification; those which are common to the greatest number of plants being used for the primary grand divisions; those less comprehensive for subordinate groups, &c.; so that the *character* (505), or description of each group, when fully given, actually expresses all the known particulars in which the plants it embraces agree among themselves, and differ from other groups of the same rank. This complete analysis being carried through the system, from the primary divisions down to the species, it is evident that the study of a single plant of each group will give a correct (so far as it goes), and often a sufficient, idea of the structure, habits, and even the sensible properties of the whole.

515. What we call a natural method, it may here be remarked, is so termed merely because it expresses the natural relationship of plants, as far as practicable; for every form yet contrived, or likely to be devised, is, to a considerable extent, artificial: 1st. Because the affinities of a particular group cannot be fully estimated until all its

members are known; and thus the progress of discovery leads to changes, or modifies our views, as in every other department of knowledge. 2d. Because the boundaries of groups are not so arbitrarily circumscribed in nature, as they necessarily are in our classifications; but individuals depart from the assigned limits in various directions (like rays from a centre); the "edge of difference being, as it were, softened down by an easy transition." 3d. Because that, even supposing the groups to be perfectly natural, and their affinities completely understood, it is impossible to arrange them in a single continuous series, in such a manner that each shall be preceded and followed by its nearest allies; since the same family, for instance, may be about equally related to three or four others, only two of which points, at best, can be indicated in the lineal series which must be adopted in books. And 4th. We are still obliged to use avowedly artificial characters, for the sake of convenience; as in the arrangement of the numerous orders of Exogenous Plants into the Polypetalous, Monopetalous, and Apetalous divisions of the series, although different genera of the same order, or different species of the same genus, may present these very diversities.

516. In explaining the general principles of classification, we proceeded from the species to the class; showing how groups of successive rank arise from the consideration of points of agreement. In applying them to the actual distribution of plants according to the received mode of classification, it will be more convenient to pursue the analytical course, and to show how the vegetable kingdom, taken as a whole, is divided and subdivided by regarding the points of difference.

517. The general plan, upon which the vegetable creation is constituted, it has been the object of the whole former part of this treatise to illustrate: the fundamental

principles of natural history classification have also been cursorily expounded in a preceding chapter (494). In applying the one to the other, we have to consider, in the first place, how the long series, reaching from the highest Flowering Plants to the lowest and minutest Fungi and Algæ, can be primarily divided. As already intimated, the most decided break in the series occurs between the flower-bearing and the flowerless plants; the first producing proper flowers (with stamens and pistils) and seeds containing a ready formed embryo; while in the second, these are replaced by a more or less analogous, but simpler and more recondite apparatus. We need only refer to those paragraphs in which the difference is brought to view (51, 456, 459, &c.). The vegetable kingdom, viewed under this aspect, is therefore primarily divided into two minor series, a higher and a lower, the FLOWERING and the FLOWERLESS, or (under other and older names) the PHÆNOGAMOUS (or Phanerogamous) and the CRYPTOGAMOUS Plants.

518. Let us next consider how the higher series, embracing still the largest part as well as the most complex forms of the vegetable kingdom, may itself be divided, in view of the most general and important points of difference which the plants it comprises exhibit. Whenever they rise to arborescent forms, a difference in port and aspect at once arrests attention; that which distinguishes our common trees and shrubs from Palms and the like (Fig. 98^2, 63). On examination, this difference is found to be connected with an important difference in the structure of the stem or wood, and in its mode of growth. The former present the exogenous, the latter the endogenous structure or growth (94 – 99, 101, 122). This difference is manifest, although not so striking, in the annual or herbaceous stems of these two sorts of Flowering Plants. A difference is also apparent in their foliage; the former generally have *reticu-*

lated, or *netted-veined;* the latter parallel-veined leaves (150). The leaves of the former usually fall off by an articulation; those of the latter decay on the stem (191). The Flowering series, therefore, divides into two great classes, namely, into Exogenous and Endogenous Plants or, more briefly, into Exogens and Endogens. The difference between the two not only pervades their whole port and aspect, but is manifest from the earliest stage. The embryo of Exogens, as already shown, is provided with a pair of cotyledons; that of Endogens with only one; whence the former are also termed Dicotyledonous, and the latter Monocotyledonous Plants: names introduced by Jussieu, the father of this branch of botany. We employ sometimes the one and sometimes the other of the two sorts of names for these two great classes.

519. In contemplating the Exogenous or Dicotyledonous class, we find that two sets of the plants it comprises are specially distinguished by a great simplicity in their organs of fructification, approximating not indistinctly to that still greater simplicity which characterizes the highest Flowerless Plants (466). These are the Coniferous trees, such as Pines, Firs, &c., and that small and singular tribe of Endogenous port but essentially Exogenous structure, which comprises the Cycas and Zamia (Fig. 968): in these cases, not only are the sterile or staminate flowers reduced to the last degree of simplicity, but the fertile consist of naked ovules merely, borne on the margins or surface of a sort of open leaf, instead of being inclosed in an ovary (458, 375). They are therefore named Gymnospermous (that is, naked-seeded) Plants; and form a subordinate group, or subclass of Exogens. When it is needful to contradistinguish the great mass of Exogens from which these are thus separated, we call them Angiospermous Exogenous Plants; a name denoting that their seeds are inclosed in a

pericarp. No such reduction occurs in the Endogenous class, and consequently no equivalent subdivision is there requisite.

520. We must next consider the systematic division of the Flowerless, or Cryptogamous series. This is most readily accomplished by conceiving them to present a series of reductions or degradations of a higher type, as we have already done in a special chapter (456). In their general mode of growth and in their anatomical structure, the higher Flowerless Plants, such as Equisetums, Club-Mosses, and Ferns, do not essentially differ from Flowering Plants. All the various kinds of elementary tissue, proper woody fibre, vessels, &c. (14–35), enter into their composition (462). If we had chosen to take anatomical structure as the basis of our primary division of the whole vegetable kingdom, we might have divided the whole into *Vascular* and *Cellular* Plants, as was done by De Candolle; the former comprising the whole series from Ferns upward, the latter embracing the Mosses and all below them. Having effected the primary division, however, upon other grounds, we turn this difference to subordinate account; and therefore consider the higher Flowerless Plants, which agree with the series above them in so many respects, and which in their composition have woody tissue and vessels, to constitute the distinct class of VASCULAR FLOWERLESS Plants. For reasons already explained (462), they have also been termed ACROGENS. All the kinds below these, being composed of cellular tissue exclusively (though the cells are often drawn into tubes or filaments, which may even have a spiral fibre generated upon their walls, 25, Fig. 16), are CELLULAR Plants.

521. But the higher Cellular Plants, such as Mosses, still display the proper type of vegetation (468); they agree with those of higher grades in having an opposite growth, forming a distinct axis or stem, which grows upward by buds

and is for the most part symmetrically clothed with distinct leaves; while the Lichens, Seaweeds, and Fungi, the most imperfect of vegetables, present no distinction into stem, root, and leaves, no polarity, or growth in two opposite directions, no buds, and no organs which are clearly analogous to flowers. Their homogenous tissue often tends to the formation of flat, more or less definite expansions (the *thallus*), which is the nearest approach to any thing like leaves; in which their simple spores are embedded. Hence they are termed *Thallophytes*. If the line of primary division be drawn in view of these important distinctions, as proposed by Unger and Endlicher, the vegetable kingdom would be separated into two great, but unequal series, namely, 1st, the *Cormophytes*, or *Stem-growing Plants;* those with a distinct axis of growth, elongating downward into roots, and upward by means of buds into stems, provided with leaves, and with reproductive organs analogous to flowers; and 2d, the *Thallophytes;* which are stemless, rootless, leafless, and in every sense flowerless (470).

522. Following the plan we have adopted, however, we have only to distinguish this higher grade of Flowerless Cellular Plants, exhibiting a distinct stem, &c., as a separate class, the Anophytes, represented by the Mosses, which, although of the simplest anatomical structure, still emulate the higher or typical forms. The remainder, as already defined (521, 470), embracing the Lichens, Fungi, and Algæ, form the last and lowest class, the Thallophytes. To consider their subordinate arrangement would quite surpass our limits.

523. The general plan may be analytically expressed by the following schedule.

Synoptical View of the Classes in the Natural System.

- **Ser. I. FLOWERING PLANTS, with**
  - Exogenous growth and a dicotyledenous embryo. Class I. EXOGENS, or DICOTYLEDONS.
    - Seeds in a pericarp. Subcl. 1. Angiosperms.
    - Seeds naked. 2. Gymnosperms.
  - Endogenous growth and a monocotyledoneus embryo. " II. ENDOGENS, or MONOCOTYLEDONS.
- **Ser. II. FLOWERLESS PLANTS, with**
  - a distinct axis, or stem and foliage, containing
    - woody and vascular tissue. Class III. ACROGENS.
    - cellular tissue only. " IV. ANOPHYTES.
  - no distinction of stem and foliage, but a thallus. " V. THALLOPHYTES.

524. These five classes are very unequal, in respect to the number of plants they embrace; the Exogenous class containing much the largest number of species as well as orders; the Endogens also comprising numerous types; but the others very few in comparison. Convenience of analysis therefore requires that the larger classes should be broken up into divisions, alliances, cohorts, or by whatever name groups intermediate between the classes and orders may be termed: and the accomplishment of this object, so as to form natural groups, is at present the great desideratum in Systematic Botany. But until this be well done, we are obliged to use artificial analyses of the classes, or to throw the orders into groups, which, in proportion as they are rendered natural, it becomes impossible strictly to circumscribe. In this view, the great class of Exogenous plants is usually broken up into three very convenient, but nearly artificial divisions (515) founded on the presence, absence, or union of the petals, namely:

1. POLYPETALÆ, the Polypetalous Exogens; where the calyx and corolla are both present, and the latter composed of distinct petals (226).
2. MONOPETALÆ, the Monopetalous Exogens; where the petals are united.
3. APETALÆ, the Apetalous Exogens; where the petals are wanting, and the floral envelopes, if present at all, consist of the calyx alone.

525. These divisions, as well as the other classes, are subdivided by different authors in various ways, which need not be specified; since it is only the classes and the orders that are considered to rest upon a stable basis.

526. The orders, or families, are to be viewed rather as natural groups of genera, than as subdivisions of the classes. The kind of characters employed in distinguishing them

will best be learned from the succeeding illustrations. Their names, which are always plural, sometimes express a characteristic feature of the group; as, for instance, *Leguminosæ*, or the Leguminous plants, such as the Pea, Bean, &c., whose fruit is a legume (415); *Umbelliferæ*, or Umbelliferous plants, so named from having the flowers in umbels; *Compositæ*, an order having what were termed compound flowers by the earlier botanists (269); *Labiatæ*, so called from the labiate or two-lipped corolla (309), which nearly all the species exhibit; *Cruciferæ*, which have their four petals disposed somewhat in the form of a cross, &c. But more frequently, and indeed as a general rule, the name is formed from that of some leading or well known genus, which is prolonged into the adjective termination *aceæ*. Thus, the plants of the order which comprises the Mallow (*Malva*), are called *Malvaceæ;* that is, *Plantæ Malvaceæ*, or in English, Malvaceous plants: those of which the Rose (*Rosa*) is the well known representative are *Rosaceæ*, or Rosaceous plants, &c. This termination in *aceæ* being reserved for orders, should not be applied to suborders or tribes; which usually bear the name of their principal or best known genus in an adjective form, without such prolongation. Thus the genus *Rosa* gives name to a particular tribe, *Roseæ*, of the order *Rosaceæ;* the genus *Malva* to the tribe *Malveæ* of the order *Malvaceæ*, &c.*

* The advantage of uniformity in the termination of ordinal names will be thought to counterbalance the awkwardness of such names as *Aceraceæ* instead of Acerineæ, *Oxalidaceæ* instead of Oxalideæ, *Grossulaceæ* instead of Grossulariæ, *Scrophulariaceæ* instead of Scrophularineæ, &c.; but the rule is only applicable to ordinal names derived from those of genera; and affords no sanction to the absurd change of Leguminosæ into *Leguminaceæ*, Labiatæ into *Labiaceæ*, Cruciferæ into *Cruciaceæ*, &c., names which are formed upon a different principle. The appellations

527. The number of genera in an order is quite as indefinite as that of the orders in a class, or other great division. While some orders are constituted of a single genus, as Equisetaceæ, Grossulaceæ, &c. (just as many genera contain but a single known species), others comprise a large number; nearly nine hundred being embraced in the last general enumeration of the Compositæ. The names of genera are Latin substantives, in the singular number, and mostly of Greek or Latin derivation. Those which were known to the ancients generally preserve their classical appellations (Ex. *Fagus*, *Prunus*, *Myrtus*, *Viola*, &c.); and even the barbarous or vulgar names of plants are often adopted, when susceptible of a Latin termination, and not too uncouth; for example, *Thæa* and *Coffæa*, for the Tea and Coffee plants, *Bambusa* for the Bamboo, *Yucca*, *Negundo*, &c. But, more commonly, generic names are formed to express some botanical character, habit, or obvious peculiarity of the plants they designate; such as *Arenaria*, for a plant which grows in sandy places, *Dentaria*, for a plant with toothed roots, *Lunaria*, for one with moon-shaped pods, *Sanguinaria*, for the Blood-root, *Crassula*, for some plants with remarkably thick leaves. These are instances of Latin derivatives; but recourse is more commonly had to the Greek language, especially for generic names composed of two words; such as *Menispermum*, or Moon-seed; *Lithospermum*, for a plant with stony seeds; *Melanthium*, for a genus whose flowers turn of a black or dusky color; *Epidendrum*, for Orchideous plants which grow upon trees; *Liriodendron*, for a tree which bears lily-shaped flowers,

---

Graminaceæ (instead of Gramineæ) and *Palmaceæ* (instead of Palmæ) are equally objectionable; the former not being *Plantæ Graminaceæ*, but Grasses; the latter not *Plantæ Palmaceæ*, but Palms: and so likewise of Algæ, Fungi, &c.

&c. Genera are also dedicated to distinguished persons, a practice commenced by the ancients; as in the case of *Pæonia*, which bears the name Pæon, who is said to have employed the plant in medicine; and *Euphorbia*, *Artemisia*, and *Asclepias*, are also examples of the kind. Modern names of this kind are given in commemoration of botanists, or of persons who have contributed to the advancement of natural history. *Magnolia*, *Bignonia*, *Lobelia*, and *Lonicera*, dedicated to Magnol, Bignon, Lobel, and Lonicer, are early instances of the practice; Linnæa, Tournefortia, Jussiæa, Gronovia, &c., bear the names of more celebrated botanists; and at the present day almost every devotee or patron of the science is thus commemorated.

528. The names of species, as a general rule, are adjectives, written after those of the genera, and established on similar principles; as, *Magnolia grandiflora*, the Large-flowered Magnolia; *M. macrophylla*, the Large-leaved Magnolia; *Bignonia radicans*, the Rooting Bignonia, &c. The generic and specific names, taken together, constitute the proper scientific appellation of the plant. Specific names sometimes distinguish the country which a plant inhabits (Ex. *Viola Canadensis*, the Canadian Violet), or the station where it naturally grows (as *V. palustris*, which grows in swamps, *V. arvensis*, in fields, &c.), or they express some obvious character of the species; as, *V. rostrata*, where the corolla bears a remarkably long spur; *V. tricolor*, which has tri-colored flowers; *V. rotundifolia*, with rounded leaves; *V. lanceolata*, with lanceolate leaves; *V. pedata*, with pedately parted leaves; *V. primulæfolia*, where the leaves are compared to those of the Primrose; *V. asarifolia*, where they are likened to those of Asarum; *V. pubescens*, which is hairy throughout, &c. Frequently the species bears the name of its discoverer or describer,

when it takes the genitive form, as *Viola Muhlenbergii*, *V. Nuttallii*, &c. When such commemorative names are merely given in compliment to a botanist unconnected with the discovery or history of the plant, the adjective form is preferred; as, *Carex Torreyana*, *C. Hookeriana*, &c.: but this rule is not universally followed. Specific names are sometimes substantive; as, *Ranunculus Flammula*, *Hypericum Sarothra*, *Linaria Cymbalaria*, &c.; when they do not necessarily accord with the genus in gender. These, as well as all specific names derived from those of persons or countries, should always be written with a capital initial latter.

529. In an exposition of the natural system, some authors (such as Jussieu and Endlicher) commence with the lower extremity of the series, and end with the higher; while others (as De Candolle) pursue the opposite course, beginning with the most perfect Flowering Plants, and concluding with the lowest grade of Flowerless Plants. The first mode possesses the advantage of ascending by successive steps from the simplest to the most complex structure; the second, that of passing from the most complete and best understood to the most reduced and least known forms; or, in other words, from the easiest to the most difficult; and is therefore the preferable plan.

530. The arrangement of De Candolle, being most in use, has been followed as nearly as practicable in the following illustrations, so far as relates to the series of the orders; while these have at the same time been thrown into small, and more or less artificial groups, for convenience of analysis. The conspectuses of the characters of these groups, imperfect as they must be, will serve as a kind of key to the orders of each class or subclass, and facilitate in some degree the student's investigation.* It is by no means

* In a Flora, or other systematic work based on the natural system, artificial analyses, contrived in various ways, are necessary

necessary, or desirable, to introduce into our elementary illustrations the little known and unimportant orders, especially those which have no indigenous, naturalized, or commonly cultivated representatives in the United States. Those more important exotic families, however, which would otherwise be omitted, are mentioned in the form of notes, placed at the bottom of the page, under the indigenous orders to which they are respectively related. Full descriptions of the orders have not been attempted, but the easier distinguishing characters are given, to the exclusion of the non-essential. An explanation of the technical terms, which, for obvious reasons, are freely employed (and which will serve to initiate the student into the language of descriptive botany), may be sought in the combined glossary and index at the end of the volume.

CHAPTER IV.

ILLUSTRATIONS OF THE NATURAL ORDERS OR FAMILIES.

Series I. — Flowering, or Phænogamous Plants.

Plants furnished with flowers (essentially consisting of stamens and pistils), and producing proper seeds (457).

---

to the unpractised student, and afford him great assistance in disentangling the more or less complicated characters of the orders. But they are hardly necessary in our sketch, which is intended to give a cursory general view of the principal natural orders, rather than a particular and systematic analysis.

Class I. — Exogenous or Dicotyledonous Plants.

Stem consisting of a distinct bark and pith, which are separated by an interposed layer of woody fibre and vessels, forming *wood* in all perennial stems: increase in diameter effected by the annual deposition of new layers between the old wood and the bark, which are arranged in concentric zones (98 – 121), and traversed by medullary rays. Leaves commonly articulated with the stem (191), their veins branching and reticulated (149). Sepals and petals, when present, more commonly in fives or fours, and very rarely in threes. Embryo with two or more cotyledons (100, 443).

Subclass I. — Angiospermous Exogenous Plants.

Ovules produced in a closed ovary (357, 375), and fertilized by the action of pollen through the medium of a stigma. Embryo with a pair of opposite cotyledons (443).

Division I. — Polypetalous Exogenous Plants.

Floral envelopes consisting of both calyx and corolla; the petals distinct (333).*

Conspectus of the Groups and Orders.

Group 1. Ovaries several or numerous (in a few cases solitary), distinct, when in several rows sometimes cohering in a mass, but not united into a compound pistil. Petals and stamens inserted on the receptacle.

*** Stamens or pistils (one or both) numerous or indefinite.**

1. Ranunculaceæ.
2. Magnoliaceæ.
3. Schizandraceæ.
4. Anonaceæ.

*** * Stamens few or definite. Pistils very few or solitary.**

5. Menispermaceæ.
6. Berberidaceæ.

* Some cases of polypetalous flowers also occur in the orders Ericaceæ, Aquifoliaceæ, and Plumbaginaceæ; which are placed in the Monopetalous part of the series.

Group 2. Ovaries several, either distinct, or perfectly united into a compound pistil of several cells. Stamens indefinite, inserted on the receptacle or torus. — Aquatic herbs.

* Carpels not united into a compound ovary.

7. Cabombaceæ. 8. Nelumbiaceæ.

* * Ovary compound, the seeds covering the dissepiments.

9. Nymphæaceæ.

* * * Ovary compound, the placentæ in the axis.

10. Sarraceniaceæ.

Group 3. Ovary compound, with parietal placentæ. Calyx free from the ovary; the stamens and petals inserted on the receptacle. Leaves not dotted. (Cf. groups 4 and 16.)

* Flowers either irregular or unsymmetrical; the stamens being either indefinite, or not exactly equal to or double the petals when the corolla is regular. Styles or stigmas united.

+ Sepals 2, or rarely 3, deciduous.

11. Papaveraceæ. 12. Fumariaceæ.

+ + Sepals and petals 4, or rarely 6.

13. Cruciferæ. 14. Capparidaceæ.

15. Resedaceæ.

+ + + Sepals 5, persistent.

16. Violaceæ. 17. Cistaceæ.

* * Flowers symmetrical and regular. Styles or stigmas separate.

18. Droseraceæ.

Group 4. Ovary compound with the placentæ parietal, or 2–5-celled from their meeting in the axis: styles distinct, or partly united. Stamens and petals inserted on the receptacle; the former often polyadelphous or in three or more clusters. Seeds with a straight embryo and little or no albumen. — Leaves dotted.

19. Hypericaceæ. 20. Elatinaceæ.

Group 5. Ovary compound, one-celled, with a free central placenta, or several-celled with the placentæ in the axis. Calyx free from the ovary, or nearly so. Embryo coiled around the outside of the albumen!

* Petals 3–5 or 6, rarely wanting.

21. Caryophyllaceæ. 22. Illecebraceæ.

23. Portulacaceæ.

* * Petals numerous. Ovary many-celled.

24. Mesembryanthemaceæ.

Group 6. Ovary compound and several-celled, with the placentæ in the axis: or the numerous carpels more or less coherent with each other or with a central axis. Calyx free from the ovary, with a valvate æstivation. Stamens indefinite, monadelphous, or polyadelphous, inserted with the petals into the receptacle or base of the calyx.

25. Malvaceæ. 26. Tiliaceæ.

Group 7. Ovary compound, with two or more cells, and the placentæ in the axis, free from the calyx, which is imbricate in æstivation. Stamens indefinite, or twice as many as the petals, usually monadelphous, inserted into the receptacle. — Trees or shrubs.

27. Ternstrœmiaceæ. 29. Meliaceæ.
28. Aurantiaceæ, 30. Cedrelaceæ.

Group 8. Ovary compound, or of several carpels adhering to a central axis, free from the calyx, which is mostly imbricated in æstivation. Stamens as many or twice as many as the petals, inserted on the receptacle, commonly monadelphous at the base. — Flowers perfect.

* Flowers regular or nearly so. Calyx imbricate.

31. Linaceæ. 32. Geraniaceæ.
33. Oxalidaceæ.

* * Flowers irregular and unsymmetrical.

34. Balsaminaceæ. 35. Tropæolaceæ.

* * * Flowers regular. Calyx valvate.

36. Limnanthaceæ.

Group 9. Ovary compound, with 2–several cells; or carpels several and more or less united by their styles. Calyx free. Petals as many as the sepals, or rarely wanting. Stamens once or twice as many as the sepals, distinct, inserted into the receptacle or base of the calyx. — Flowers often diœcious or polygamous.

37. Zygophyllaceæ. 39. Anacardiaceæ.
38. Rutaceæ. 40. Zanthoxylaceæ.

Group 10. Ovary compound, 2–3-lobed, 2–3-celled, free from the calyx, which is imbricated in æstivation. Petals usually irregular, one fewer than the sepals, or sometimes wanting. Stamens definite, distinct, inserted on or around a hypogynous disk. — Flowers often polygamous.

41. Aceraceæ. 42. Hippocastanaceæ.
43. Sapindaceæ.

Group 11. Ovary compound, 2–5-celled. Calyx free from, or adherent to the base of the ovary. Petals and stamens equal in number to the lobes of the calyx, and inserted either into its base or throat, or upon the disk that covers it. — Shrubs or trees. Flowers regular.

* Stamens alternate with the petals.

44. CELASTRACEÆ.

* * Stamens opposite the petals!

45. RHAMNACEÆ. 46. VITACEÆ.

Group 12. Ovary compound, 2-celled, free from the calyx. Sepals and petals very irregular. Stamens monadelphous; the tube of filaments split on one side, and more or less united with the claws of the hypogynous petals: the anthers one-celled, and opening by a pore at the apex! Seeds albuminous.

47. POLYGALACEÆ.

Group 13. Ovary simple and solitary, free from the calyx; the fruit a legume. Corolla papilionaceous, or sometimes regular. Stamens monadelphous, diadelphous, or distinct. Seeds destitute of albumen.

48. LEGUMINOSÆ.

Group 14. Ovaries one or several, simple and distinct, or combined into a compound ovary, with two or more cells and the placentæ in the axis. Petals and the distinct stamens inserted on the calyx. Seeds destitute of albumen.

* Calyx free, although often inclosing the ovaries in its tube, except when the latter are united, when it is adnate to the compound ovary, and the stamens are indefinite.

49. ROSACEÆ. 50. CALYCANTHACEÆ.

51. MYRTACEÆ.

* * Calyx adhering merely to the angles of the ovary. Anthers opening by pores.

52. MELASTOMACEÆ.

* * * Calyx entirely free from the compound ovary.

53. LYTHRACEÆ.

* * * * Calyx adherent to the compound ovary. Stamens definite.

54. ONAGRACEÆ. 55. COMBRETACEÆ.

56. RHIZOPHORACEÆ.

Group 15. Ovary compound, one-celled, with parietal placentæ. Petals and (with one exception) the stamens inserted on the throat of the calyx. Flowers perfect, except in Papayaceæ.

* Calyx adherent to the ovary.

57. LOASACEÆ. 58. CACTACEÆ.
59. GROSSULACEÆ.

* * Calyx free from the ovary.

60. TURNERACEÆ. 61. PASSIFLORACEÆ.
62. PAPAYACEÆ.

Group 16. Ovary compound, 2–several-celled (or one-celled by obliteration); the placentæ arising from the axis, but carried outwards to the walls of the pericarp. Calyx adherent. Corolla frequently monopetalous. Stamens united either by their filaments or anthers. Flowers diœcious or monœcious.

63. CUCURBITACEÆ.

Group 17. Ovaries two or more, many-ovuled, distinct, or partly, sometimes completely, united, when the compound ovary is either one-celled with parietal placentæ, or two or more celled with the placentæ in the axis. Calyx either free from the ovary, or adherent in various degrees. Petals and stamens inserted on the calyx; the latter most definite. Seeds albuminous, numerous.

64. CRASSULACEÆ. 65. SAXIFRAGACEÆ.

Group 18. Ovary compound, 2- (rarely 3–5-) celled, with a single ovule suspended from the apex of each cell. Stamens usually as many as the petals, or lobes of the adherent calyx.

* Summit of the (often 2-lobed) ovary free from the calyx; the petals and stamens inserted on the throat of the calyx.

66. HAMAMELACEÆ.

* * Calyx-tube entirely adherent to the ovary. Stamens and petals epigynous.

67. UMBELLIFERÆ. 69. CORNACEÆ.
68. ARALIACEÆ. 70. LORANTHACEÆ.

Group 1. *Ovaries several or numerous* (*solitary in* Berberidaceæ *and a few other cases*), *distinct; when in several rows sometimes coherent to each other, but not united into a compound pistil. Petals and stamens inserted on the receptacle* (*hypogynous*). *Seeds albuminous.*

Order 1. RANUNCULACEÆ. Herbaceous, occasionally climbing plants, with an acrid watery juice, and usually palmately or ternately lobed or divided leaves, without stipules.—Calyx of three to six, usually five, distinct sepals, deciduous, except in Pæonia and Helleborus. Petals five to fifteen, or sometimes none. Stamens indefinite, distinct. Ovaries numerous, rarely few or solitary, distinct. Embryo minute, at the base of firm albumen.

Ex. Ranunculus, the Butter-cup (Fig. 347–350), which

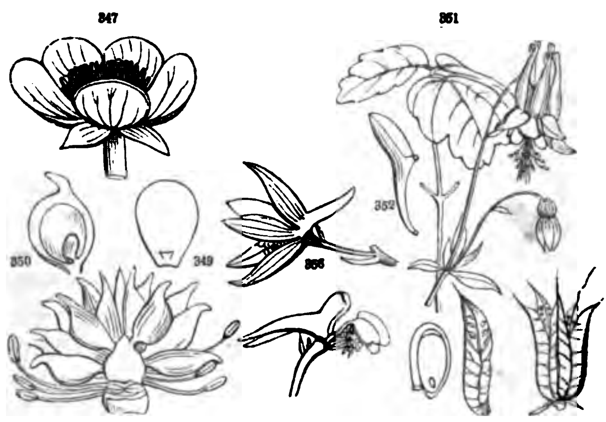


FIG. 347. Flower of a Ranunculus. 348. Vertical section through the receptacle; the sepals, petals, and most of the stamens taken away. 349. A petal, with the nectariferous scale at its base. 350. Section through an ovary, showing the solitary ovule attached to the base of the cell.

FIG. 351. Flower and part of a leaf of Aquilegia Canadensis (Wild Columbine). 352. A detached petal. 353. The five carpels (follicles, 414) of the fruit. 354. A separate follicle. 355. Vertical section of the seed, showing the minute embryo.

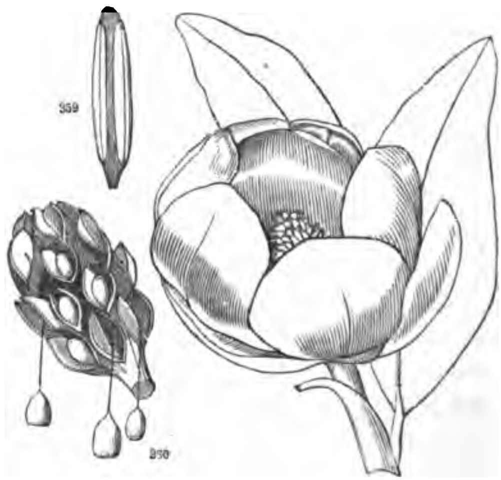
FIG. 356. Flower of Delphinium, or Larkspur, with its spurred calyx; which is removed in 357, to show the four irregular petals and the stamens.

has regular flowers with petals. Clematis (Virgin's Bower), Anemone, and Hepatica (Liver-leaf), which have no petals, but the calyx is petaloid: the latter has an involucre entirely resembling a calyx, and the leaves of the former are opposite. In all these examples the ovaries are one-seeded, and the flowers regular. In others, the ovaries contain several seeds, and the flowers are irregular, or with the petals in the form of spurs or different shaped bodies. Actæa (Cohosh, Bane-berry) and one Larkspur have a solitary ovary: in the latter the petals are consolidated. Zanthoriza (Yellow-Root) has only five or ten stamens. — The juice of all Ranunculaceous plants is acrid, or even caustic: some are virulent narcotico-acrid poisons.

ORDER 2. MAGNOLIACEÆ. Trees or shrubs; with ample and coriaceous, alternate, entire or lobed (never serrate) leaves, usually punctate with minute transparent dots: stipules membranaceous, either rolled up one around each leaf in the bud, as in Magnolia, or applied to each other face to face in pairs, as in the Tulip-tree, falling off when the leaves expand. Flowers solitary, large and showy, mostly odorous. — Calyx of three to six deciduous sepals, colored like the petals: the latter three or several, often in several rows. Stamens numerous, mostly with short filaments, and long adnate (introrse) anthers. Carpels either several in a single row, or numerous and spicate on the prolonged receptacle; in the latter case usually more or less cohering with each other, and forming a fruit like a cone or strobile. Seeds mostly one or two in each carpel, often with a pulpy exterior covering, and suspended, when the carpels open, by an extensile funiculus, composed of unrolled spiral vessels. Embryo minute, at the base of fleshy albumen.

Ex. Magnolia (Fig. 358 – 360), in which the hard or

woody carpels are persistent, and accordingly open by the dorsal suture; Liriodendron (the White-wood or Tulip-tree), in which the winged carpels fall away from the receptacle, but are themselves indehiscent. Illicium, the Star Anise, gives name to the tribe which has the carpels in a single whorl. Bitter and aromatic properties pervade the order.



ORDER 3. SCHIZANDRACEÆ. A very small family, differing from the preceding chiefly in being twining or trailing shrubs, destitute of aroma or bitterness, but with a mucous juice and somewhat toothed leaves, without stipules; the flowers monœcious or diœcious; the anthers coherent with each other.

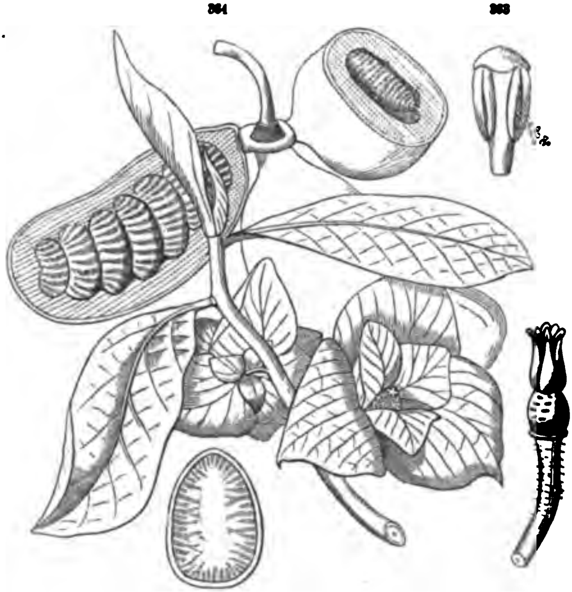
Ex. Schizandra of the Southern United States: Sphærostemma and Kadsura of Eastern Asia.

FIG. 358. Magnolia glauca. 359. A stamen, seen from the inside, showing the two lobes of the adnate anther. 360. The carpels in fruit, persistent on the receptacle, and opening by the dorsal suture; the seeds suspended by their extensile cord of spiral vessels.

ORDER 4. ANONACEÆ. Trees or shrubs, with alternate entire leaves, destitute of stipules. Flowers large, but dull colored. — Calyx of three persistent sepals. Corolla of six petals in two rows, with a valvate æstivation. Stamens numerous, in many rows, with extrorse anthers. Carpels few, or mostly numerous and closely packed together, sometimes cohering and forming a fleshy or pulpy mass in the mature fruit. Seeds one or more in each carpel, with a brittle testa: embryo minute at the base of hard, ruminated albumen (437).

Ex. Our four species of Papaw are our only representa-

364 363

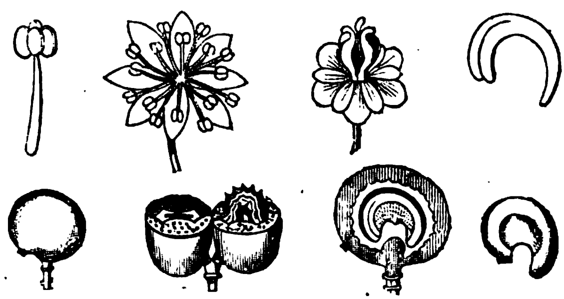


365 361 362

FIG. 361. Flowering branch of the Papaw (Uvaria triloba) of the natural size. 362. The receptacle, with all but the pistils removed. 363. A stamen magnified. 364. View of three baccate pods from the same receptacle (much reduced in size); one cut across, the other lengthwise, to show the large bony seeds. 365. Section of the seed, to show the ruminated albumen.

tives of this chiefly tropical order, which also furnishes the luscious Custard apples of the East and West Indies, &c. Aromatic, and sometimes rather acrid, properties prevail in the order.

367 366 368 373



369 370 371 372

ORDER 5. MENISPERMACEÆ. Climbing or twining shrubby plants; with alternate and simple palmately-veined leaves, destitute of stipules; and small flowers in racemes or panicles, diœcious, monœcious, or polygamous. — Calyx of three to twelve sepals, in one to three rows, deciduous. Petals as many as the sepals or fewer, small, or sometimes wanting in the pistillate flowers. Stamens as many as the

---

ORDER MYRISTICACEÆ, consisting of a few tropical trees (which bear nutmegs), differs from Anonaceæ in having monœcious or diœcious and apetalous flowers. The aril and the albumen of the seeds are fine aromatics. The common *nutmeg* is the seed of Myristica moschata (a native of the Moluccas) deprived of the testa: *mace* is the aril of the same species. The *ruminated* albumen (437), is nearly peculiar to this family and the Anonaceæ.

FIG. 366. Staminate flower of Menispermum Canadense. 367. A stamen, with its four-lobed anther. 368. A pistillate flower of the same. 369. A solitary fruit. 370. Two drupes on the same receptacle, cut across; one through the pulpy exocarp only, the other through the bony endocarp and seed. 371. A drupe divided vertically. 372. The seed, and 373, the coiled embryo detached.

petals, and opposite them, or two to four times as many: anthers often four-celled. Carpels usually several, but only one or two of them commonly fructify, at first straight, but during their growth often curved into a ring; in fruit becoming berries or drupes. Seeds solitary, filling the cavity of the bony endocarp: embryo large, inclosed in the thin, fleshy albumen.

Ex. Menispermum, or Moonseed (Fig. 366–373), Cocculus. The roots are mostly bitter and tonic (e. g. *Columbo Root* of the Materia Medica); but the fruit is often narcotic and acrid; as, for instance, the *Cocculus Indicus* of the shops, so extensively used for rendering malt liquors more intoxicating, and for stupefying fishes.

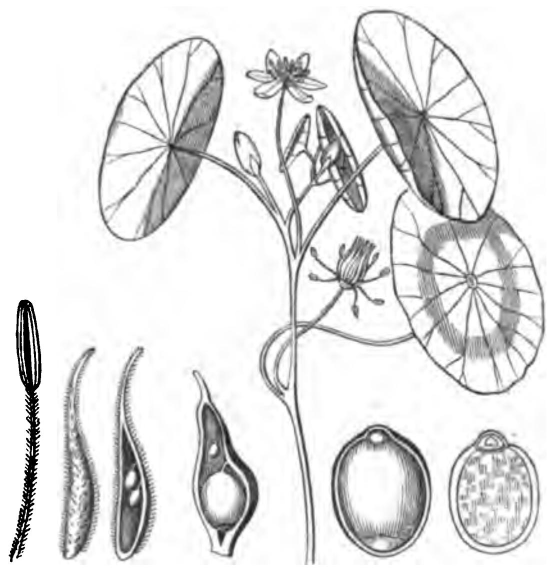
ORDER 6. BERBERIDACEÆ. Herbs or shrubs, with a watery juice; the leaves alternate, compound or divided, usually without stipules. Flowers perfect.—Calyx of three to nine sepals, imbricated, in one to several rows, often colored. Petals as many as the sepals and in two sets, or twice as many, with a pore, spur, or glandular appendage at the base. Stamens equal in number to the petals and opposite them, or rarely more numerous; anthers extrorse, the cells commonly opening by an uplifted valve. Carpel solitary, often gibbous or oblique, forming a one-celled pod or berry in fruit. Seeds sometimes with an aril: embryo (often minute) surrounded with fleshy or horny albumen.

Ex. The Barberry (Fig. 374–382), the sharp spines of which are transformed leaves (187); the Mahonias are Barberries with pinnated leaves. Leontice (Caulophyllum) thalictroides, the Blue Cohosh, is remarkable for its evanescent pericarp (375), and the consequent naked seeds, which resemble drupes. Podophyllum (the Mandrake), presents an exception to the ordinal character, having somewhat numerous stamens, with anthers which do not open by valves; but the latter anomaly is also found in Nandina. The order is

remarkable for this valvular dehiscence of the anthers, and for the situation of both the stamens and petals opposite the sepals. But this latter peculiarity is doubtless owing to the production of two or three whorls both of the petals and the stamens, which does away with the anomaly. The æstivation in Berberis clearly shows this to be the case. The fruit is innocent or eatable; the roots and also the herbage sometimes poisonous.

FIG. 374. A shoot of Berberis vulgaris, the common Barberry. 375. A flowering branch from the axil of one of its leaves or spines the following year. 376. An expanded flower. 377. A petal, nectariferous near the base. 378. A stamen; the anther opening by uplifted valves. 379. Cross section of a young fruit. 380. Vertical section; the seeds attached at the base. 381. Vertical section of a seed enlarged, showing the large embryo with foliaceous cotyledons and a taper radicle, surrounded by albumen. 382. The embryo separate.

Group 2. *Ovaries several or numerous, separate, or perfectly united into a compound pistil, which is several-celled, with the placentæ not parietal. Stamens indefinite, inserted on the receptacle or torus. — Aquatic herbs. Leaves involute in vernation.*



384 385 386 387 383 388 389

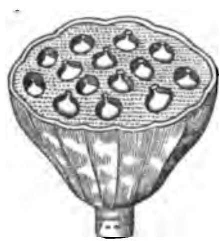
ORDER 7. CABOMBACEÆ. Aquatic herbs, with the floating leaves entire and centrally peltate; the submersed foliage sometimes dissected. Flowers solitary, rather small. — Calyx of three or four sepals, colored inside, persistent. Corolla of as many persistent petals. Stamens six to thirty-

FIG. 383. Brasenia peltata (Water-shield); the lower flower with the floral envelopes and a part of the stamens removed. 384. A magnified stamen. 385. A magnified carpel. 386. The same divided lengthwise, showing the ovules attached to the outer or dorsal suture! 387. Section of a carpel, in fruit. 388. A magnified seed, with half the outer integument removed, displaying at the upper extremity the bag which contains the embryo. 389. A magnified section through the middle of the albumen, &c.; bringing to view the minute embryo inclosed in its sac, lying outside of the albumen, which forms the principal bulk of the seed.

six, with slender filaments and innate anthers. Carpels two to eighteen, indehiscent, with two or few (anatropous) ovules in each, inserted on the dorsal suture! Seeds pendulous, with a minute embryo inclosed in a membranous bag, which is half immersed in the albumen at the extremity next the hilum.

Ex. Brasenia, the Water-shield (Fig. 383), and Cabomba, compose this very small order; the apparently single species of the former grows both in the United States and New Holland. They may be viewed as reduced forms of Nymphæaceæ.

ORDER 8. NELUMBIACEÆ. Aquatic herbs, with very large leaves and flowers, on long stalks arising from a prostrate trunk or rhizoma, which has a somewhat milky juice: the leaves orbicular and centrally peltate.—Calyx of four or five sepals, deciduous. Petals numerous, inserted in several rows into the base of a large and fleshy obconical torus, deciduous. Stamens inserted into the torus in several rows: the filaments petaloid; the anthers adnate and introrse. Carpels several, separately immersed in hollows of the enlarged flat-topped torus or receptacle (Fig. 390), each containing a single anatropous ovule; in fruit forming hard, round nuts. Seed without albumen: embryo very large, with two fleshy cotyledons, and a highly developed plumule.


390

Ex. The order consists of the single genus Nelumbium, embracing two species; one a native of Asia, the other of the United States. They are chiefly remarkable for their very large and showy leaves and flowers. The nuts are eatable.

FIG. 390. Torus and immersed ovaries of Nelumbium.

ORDER 9. NYMPHÆACEÆ. Aquatic herbs, with showy flowers, and cordate or peltate leaves arising from a prostrate trunk or rhizoma, and raised on long stalks above the water, or floating on its surface. — Calyx and corolla of several or numerous imbricated sepals and petals, which gradually pass into each other; the former persistent; the latter inserted on the fleshy torus which surrounds or partly incloses and adheres to the pistil; the inner series gradually changing into stamens. Stamens numerous, in several rows, inserted into the torus with or above the petals; many

FIG 391 – 393. A leaf, flower-bud, and an expanded flower of Nymphæa odorata (White Water-Lily). 394. The same with the envelopes, &c., cut away, leaving one of the outer, middle, and inner rows of stamens: while 395 is an inner petal, bearing an imperfect anther at the top; all exhibiting the gradual transition of petals into stamens. 396. Transverse section of the ovary, showing the attachment of the ovules throughout the dissepiments.

of the filaments petaloid, the adnate anthers introrse. Fruit indehiscent, pulpy when ripe, many-celled, crowned with the radiate stigmas; the anatropous seeds covering the spongy dissepiments. Embryo minute, inclosed in a membranous bag, which is situated next the hilum, and half immersed in the mealy albumen.

Ex. Nymphæa, the White Water-Lily (Fig. 391); Nuphar, the Yellow Pond-Lily.

ORDER 10. SARRACENIACEÆ. Perennial herbs, growing in bogs; the (purplish or yellowish-green) leaves all radical and hollow, pitcher-shaped (Fig. 145), or trumpet-shaped. Flower solitary on a long scape. — Calyx of five persistent sepals, with three small bracts at its base. Corolla of five petals. Stamens numerous. Stigma very large and petaloid, five-angled, covering the five-celled ovary, persistent. Fruit five-celled, five-valved, with a large placenta projecting from the axis into the cells. Seeds numerous, albuminous, with a minute embryo.

Ex. Sarracenia, from which the above character is taken, was the only known genus of the order, until the recent discovery of Heliamphora in Guiana. The pitchers of the latter are represented in Fig. 144: its scape bears several flowers without petals, &c. The species of Sarracenia are all North American, and, excepting S. purpurea, are confined to the Southern States east of the Alleghanies.

Group 3. *Ovary compound (composed of two or more united carpels,) with parietal placentæ! Calyx entirely free from the ovary! Stamens and petals inserted on the receptacle; the former distinct, except in* Fumariaceæ. — *Leaves not punctate or dotted.*

ORDER 11. PAPAVERACEÆ. Herbs, with a milky or colored juice, and alternate leaves without stipules. — Calyx of two (rarely three) caducous sepals. Corolla of four to six regular petals. Stamens six to twenty-four, or numer-

ous. Fruit one-celled, either pod-shaped with two to five, or capsular with numerous parietal placentæ, from which the valves often separate in dehiscence. Seeds numerous, with a minute embryo, and copious fleshy and oily albumen.

Ex. The Poppy (Papaver), the leading representative of this small but important family, is remarkable for the extension of the placentæ so as nearly to divide the cavity of the ovary into several cells, and for the dehiscence

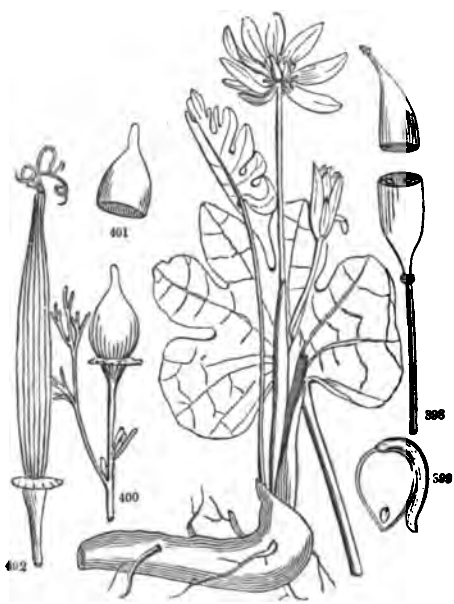


FIG. 397. Sanguinaria Canadensis (the Blood-root). 398. The pod, divided transversely, showing the parietal attachment of the seeds. 399. Longitudinal section of a magnified seed with its large raphe, showing the minute embryo, near the extremity of the albumen.

FIG. 400. Flower-bud of Eschscholtzia. 401. The calyptriform calyx detached from the base. 402. Pod of the same.

of the capsule by mere chinks or pores under the edge of the crown formed by the radiate stigmas. Sanguinaria, or Blood-root (Fig. 397). The Eschscholtzia, or Chryseis, now common in gardens, is remarkable for the expanded apex of the peduncle, and for the union of the two sepals into a *calyptra*, like a candle-extinguisher, which, separating at the base, is thrown off by the expansion of the petals (Fig. 400, 401). The colored juice is narcotic and stimulant. That of the Poppy yields *opium*.

ORDER 12. FUMARIACEÆ. Smooth herbs, with brit-

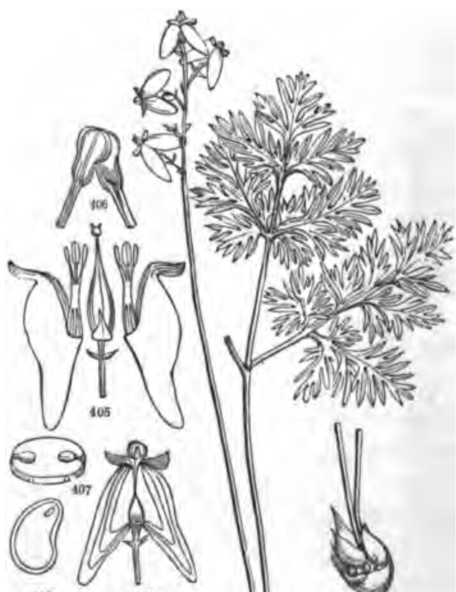


FIG. 403. Dielytra Cucullaria. 404. A flower of the natural size. 405. The same somewhat enlarged; the two spurred petals and the stamens separated; the two other petals, 406, which cohere at the tip, also removed. 407. A cross section of the pod, magnified, showing the parietal attachment of the seeds. 408. Magnified section of a seed, exhibiting the minute embryo.

tle stems, and a watery juice, alternate dissected leaves, and no stipules. Flowers irregular. — Calyx of two sepals. Corolla of four petals, in pairs; the two outer, or one of them, spurred or sac-like at the base; the iwo inner callous and cohering at the apex, including the anthers and stigma. Stamens six, in two parcels opposite the outer petals; the filaments of each set usually more or less united; the middle one bearing a two-celled anther; the lateral with one-celled or half-anthers. Fruit a one-celled and two-valved pod, or round and indehiscent. Seeds with fleshy albumen and a small embryo.

Ex. A small and unimportant tribe of plants, chiefly remarkable for their singular irregular flowers; by which alone they are distinguished, and that not very definitely, from the preceding family. A Dielytra is called *Dutchman's-breeches* (Fig. 403), from the form of the corolla; and another, *Squirrel-corn*, from the appearance of the little tubers borne at the root. Adlumia climbs by tendrils, and Fumaria has a one-seeded, nut-like fruit. The latter, and Corydalis, have only one of the outer petals spurred, or saccate.

ORDER 13. CRUCIFERÆ. Herbs, with a pungent or acrid watery juice, and alternate leaves without stipules; the flowers in racemes or corymbs, with no bracts to the pedicels. — Calyx of four sepals, deciduous. Coralla of four regular petals, with claws, their spreading limbs forming a cross. Stamens six, two of them shorter (*tetradynamous*, 310). Fruit a pod (called a *silique* when much longer than broad, or a *silicle* when short, 425), which is two-celled by a membranous partition, that unites the two marginal placentæ, from which the two valves usually fall away. Seeds with no albumen: embryo with the cotyledons folded on the radicle.

Ex. The Water-Cress, Radish, Mustard, Cabbage, &c.

A very natural order, found in every part of the world, perfectly distinguished by having six tetradynamous stamens along with four petals and four sepals, and by the peculiar pod. These plants have a peculiar volatile acridity (and often an etherial oil, which abounds in sulphur) dispersed through every part, from which they derive

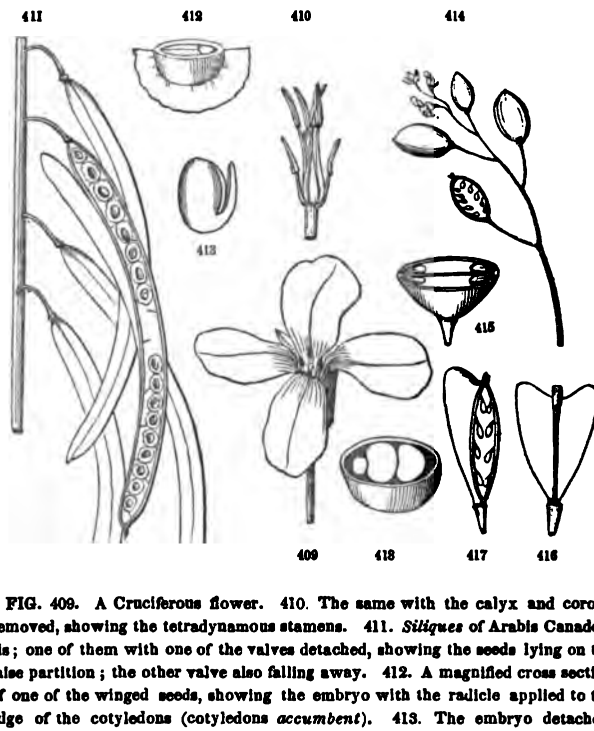
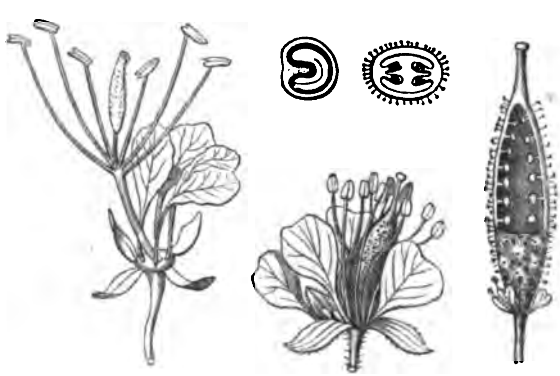


FIG. 409. A Cruciferous flower. 410. The same with the calyx and corolla removed, showing the tetradynamous stamens. 411. *Siliques* of Arabis Canadensis; one of them with one of the valves detached, showing the seeds lying on the false partition; the other valve also falling away. 412. A magnified cross section of one of the winged seeds, showing the embryo with the radicle applied to the edge of the cotyledons (cotyledons *accumbent*). 413. The embryo detached. 414. The raceme of Draba verna, in fruit. 415. A cross section of one of the *silicles*, magnified, exhibiting the parietal insertion of the seeds, and the false partition. 416. A silicle of Shepherd's Purse (Capsella Bursa Pastoris). 417. The same with one of the boat-shaped valves removed, presenting a longitudinal view of the narrow partition, &c. 418. A magnified cross section of one of the seeds, showing the embryo with the radicle applied to the side of the cotyledon (cotyledons *incumbent*).

their peculiar odor and sharp taste, and their stimulant, rubefacient, and antiscorbutic properties. The roots of some perennial species, such as the Horseradish, or the seeds of annual species, as the Mustard, are used as condiments. In some cultivated plants, the acrid principle is dispersed among abundance of saccharine and mucilaginous matter, affording wholesome food: as the root of the Turnip and Radish; the leaves, &c., of the Cabbage and Cauliflower. None are really poisonous plants, although some are very acrid. Many species are prized in cultivation; such as the Wall-flower and Stock, &c.

ORDER 14. CAPPARIDACEÆ. Herbs, or in the tropics often shrubs or trees; differing from Cruciferæ in the one-celled pod (which is often stalked) being destitute of any false partition, in the kidney-shaped seeds, and in the stamens, which, when six, are not tetradynamous, but are often more numerous.

422 421



423 419 420

FIG. 419. Flower of Polanisia graveolens. 420. Fructified ovary of the same, a portion cut away by a vertical and horizontal section, to show the single cell and two parietal placentæ. 421. Cross section of the ovary. 422. Section of the seed and embryo. 423. Flower of Gynandropsis.

30

Ex. Cleome, and Polanisia (Fig. 419–422); a small group, chiefly tropical or subtropical. Many have the pungency of Cruciferæ, but are more acrid. *Capers* are the pickled flower-buds of Capparis spinosa of the Levant, &c. The roots and herbage or bark are bitter, nauseous, and sometimes poisonous.

ORDER 15. RESEDACEÆ. Herbs, with a watery juice, and alternate leaves without stipules, except a pair of glands be so considered: the flowers in terminal racemes, small, and often fragrant. — Calyx persistent, of four to seven sepals, somewhat united at the base. Corolla of two to seven usually unequal and lacerated petals, with broad or thickened nectariferous claws. A fleshy disk is commonly present, enlarged posteriorly between the petals and the stamens, and bearing the latter, which vary from three to forty in number, and are not covered by the petals in the bud. Fruit a one-celled pod, with three to six parietal placentæ, three to six-lobed at the apex, where it opens along the inner sutures, usually long before the seeds are ripe. Seeds several or many, curved or kidney-shaped, with no albumen; the embryo incurved.

Ex. The common representative of this order is the Mignonette (Reseda odorata), prized for its fragrant flowers.

ORDER 16. VIOLACEÆ. Herbs (in tropical countries sometimes shrubby plants), with mostly alternate simple leaves, on petioles, furnished with stipules; and irregular flowers. — Calyx of five persistent sepals, often with auricles at the base. Corolla of five unequal petals, one of them larger than the others and commonly bearing a spur or sac at the base; the æstivation convolute. Stamens five, with short and broad filaments, which are usually elongated beyond the (adnate, introrse) anthers; two of them commonly bearing a gland or a slender appendage which is concealed in the spur of the corolla: the anthers approach-

ing each other, or united in a ring or tube. Style usually turned to one side, and thickened or hooded at the apex. Fruit a one-celled capsule, opening by three valves, each valve bearing a parietal placenta on its middle (407). Seeds several or numerous, anatropous, with a crustaceous integument. Embryo straight, nearly the length of the fleshy albumen.

Ex. The Violet (Viola) is the type and principal genus of this order; some species, like "the Pansy, freaked with jet," are cultivated for the beauty of their flowers; others for their delicate fragrance. The roots of all are acrid.

ORDER 17. CISTACEÆ. Herbs or low shrubby plants; with simple and entire leaves (the lower at least opposite), with or without stipules.—Calyx of five persistent sepals,

FIG. 424. Viola sagittata. 425. One of the stamens without appendage, seen from within; and one furnished with a spur-like appendage on the back. 426. A capsule which has opened and separated into three valves; the calyx still persistent. 427. A valve of the same, from which the seeds have fallen. 428. A magnified seed. 429. The same divided vertically, showing the large embryo in the midst of albumen.

the three inner with a somewhat twisted æstivation; the two outer small or sometimes wanting. Corolla of five, or rarely three, regular petals, crumpled and twisted in æstivation in the direction contrary to that of the sepals, usually ephemeral, sometimes wanting, at least in a portion of the flowers. Stamens few or numerous, distinct, with short innate anthers. Fruit a one-celled capsule with parietal placentæ, or imperfectly three to five-celled by dissepiments arising from the middle of the valves (dehiscence therefore loculicidal), and bearing the placentæ at or near the axis. Seeds few or numerous, orthotropous (with few exceptions), with mealy albumen. Embryo usually bent or spiral.

Ex. Cistus, Helianthemum (Fig. 430): a small family; the flowers often showy.

ORDER 18. DROSERACEÆ. Small herbs, growing in swamps, usually covered with gland-bearing hairs; with the

FIG. 430. The Rock Rose, Helianthemum Canadense. 431. Flower from which the petals and stamens have fallen. 432. Magnified cross section of the ovary; with a single stamen, showing its hypogynous insertion. 433. Cross section of a capsule, loculicidally dehiscent; the seeds therefore borne on the middle of each valve. 435. Vertical section of the orthotropous seed and singularly curved embryo. 436. Plan of the flower, shown in a cross section of the flower-bud.

leaves alternate, or clustered at the base of a scape, tapering into a petiole, rolled up from the apex to the base in vernation (circinate): stipules none, except a fringe of hairs or bristles at the base of the petioles. — Calyx of five equal sepals, persistent. Corolla of five regular petals, withering and persistent. Stamens as many as the petals and alternate with them, or sometimes two to three times as many, distinct, withering; anthers extrorse or innate. Styles three to five, distinct or nearly so, and each two-parted (so as to be taken for ten styles, 372, note), with the divisions sometimes two-lobed or many-cleft at the apex; sometimes

437

FIG. 437. Dionæa muscipula (Venus's Fly-trap). 438. Half of a flower divided vertically, the petals removed. 439. The divided pistil more enlarged, showing the attachment of the seeds to the base of the cell. 440. An entire pistil. 441. A seed, showing the raphe and chalaza.

all united into one. Fruit a one-celled capsule, opening loculicidally by three to five valves, with three to five parietal placentæ; in Dionæa membranaceous and bursting irregularly, with a thick placenta at the base. Seeds usually numerous. Embryo small, at the base of cartilaginous or fleshy albumen.

Ex. Drosera, the Sundew; and Dionæa (Fig. 437), so remarkable for its sensitive leaves, which suddenly close when touched (488). It is only found in the wet savannas around Wilmington, North Carolina.

Suborder? PARNASSIEÆ consists of the genus Parnassia (belonging to the northern temperate and frigid zones, and to the high mountains of tropical Asia); which differs from Droseraceæ chiefly in the want of glandular hairs, in the insertion of the petals and stamens into the very base of the calyx, and in having a cluster of sterile stamens, exterior to the five fertile ones, situated at the base of each petal. In the ovary, also, the four short stigmas are situated opposite the four parietal placentæ (372, note), and the seeds are destitute of albumen. The genus has been placed in Saxifragaceæ on account of its perigynous stamens, &c., and in Hypericaceæ on account of the sterile stamens in five sets, and the absence of albumen in the seeds.

Group 4. *Ovary compound (of two or more united carpels), with parietal placentæ, or two to five-celled by the meeting of the placentæ in the axis: the styles distinct, or partly united. Calyx entirely free from the ovary. Stamens and petals inserted on*

ORDER BIXACEÆ consists of tropical trees or shrubs, not resembling any of the other orders with parietal placentæ; and is here mentioned because Bixa Orellana, of tropical America, yields the *Arnotto* of commerce; which is the waxy, orange-red pulp that surrounds the seeds, from which it is separated by washing. It is chiefly used for staining cheese, and in the preparation of chocolate.

the receptacle; the former for the most part either cohering at the base or clustered into three or more parcels. Seeds with a straight embryo, and little or no albumen.—Leaves punctate with transparent or black dots.

443 442 444 445

ORDER 19. HYPERICACEÆ. Shrubs or herbs, with a resinous or limpid juice, and opposite entire leaves, destitute of stipules, and punctate with pellucid or blackish dots. Flowers regular.—Calyx of four or five persistent sepals, the two exterior often smaller. Petals four or five, twisted in æstivation, often with black dots. Stamens commonly polyadelphous and numerous. Capsule with septicidal dehiscence, many-seeded.

Ex. Hypericum (St. John's Wort, Fig. 442), is the type of this small family. The plants yield a resinous acid juice, and a bitter, balsamic extractive matter.

ORDER 20. ELATINACEÆ. Small annual weeds, with opposite leaves, membranaceous stipules, and minute axillary flowers.—Sepals and petals three to five. Stamens

FIG. 442. Hypericum perforatum (St. John's Wort). 443. Its tricarpellary pistil. 444. Cross section of the capsule. 445. Vertical section of a seed and its embryo.

as many or twice as many as the petals, distinct. Capsule three to five-celled, septicidal; the numerous seeds attached to a persistent central axis.

Ex. Elatine is the type of this order, containing a few insignificant weeds.

Group 5. *Ovary compound, one-celled, with a free central placenta, or two to several-celled, with the placentæ in the axis, free from the calyx or nearly so. Stamens and petals inserted on the receptacle, or into the base of the calyx, distinct. Embryo coiled around the outside of mealy albumen!*

ORDER 21. CARYOPHYLLACEÆ. Herbs, with opposite entire leaves, destitute of stipules; the stems tumid at the nodes. Flowers regular. — Calyx of four or five sepals. Corolla of four or five petals, or sometimes wanting. Stamens as many, or commonly twice as many, as the petals. Styles or stigmas two to five, distinct. Capsule

---

ORDER GUTTIFERÆ, or CLUSIACEÆ, consisting of tropical trees, with a yellow, resinous juice, large flowers, and thick and shining entire leaves, is nearly allied to Hypericaceæ, and exhibits the acrid properties of the latter family in a much higher degree. — *Gamboge* is the hardened resinous juice of the Hebradendron cambogioides of Ceylon; but the tree is supposed to have been imported from Siam by the Buddhists, to whom it is sacred, on account of the yellow color it yields. The gamboge from Siam forms the best pigment. Clusia flava yields the *Hog-gum* of Jamaica. The hot aromatic *Canella bark*, or *False Winter's bark*, is derived from the Canella alba of the West Indies. Notwithstanding the acrid properties of this order, Garcinia Mangostana of Malacca yields one of the most delicious of fruits, the *Mangosteen*.

The ORDER TAMARISCINEÆ consists of Tamarix and one or two other genera of sea-side plants, natives of Europe and Asia: they are ornamental, shrubby plants, with small scale-like and somewhat fleshy leaves, and an astringent bark.

two to five-valved, or opening only at the apex by twice as many valves as stigmas.—There are two principal suborders:

1. SILENEÆ; in which the sepals are united into a tube, and the petals and stamens are inserted on the stipe of the ovary; the former with long claws.—*Ex.* Silene, Dianthus (the Pink, Carnation).

2. ALSINEÆ; in which the sepals and petals are nearly or quite distinct; the petals destitute of claws; and the stamens inserted into the margin of a small hypogynous disk, which sometimes coheres with the base of the calyx and becomes perigynous.—*Ex.* Stellaria, Arenaria, &c. (Chickweeds, Fig. 446). Some are very ornamental; others are insignificant weeds.

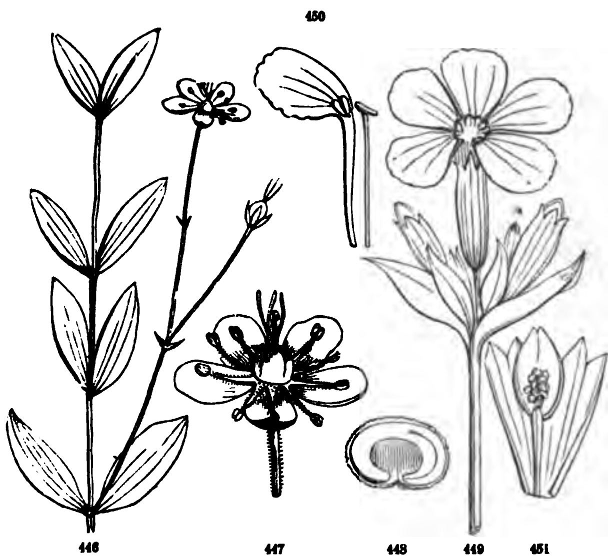


FIG. 446. Arenaria lateriflora. 447. A magnified flower. 448. Magnified section of a seed, showing the embryo coiled into a ring around the albumen. 449. Branch of Silene Pennsylvanica. 450. A petal and a stamen, detached. 451. The calyx in fruit laid open, showing the capsule and its stipe; the former divided vertically, exhibiting the free central placenta covered with seed.

ORDER 22. ILLECEBRACEÆ. Small weeds, differing from Caryophyllaceæ (tribe Alsineæ) only in having scarious stipules; flowers with inconspicuous petals, usually inserted with the (sometimes few) stamens into a disk which lines the base of the calyx, or often apetalous; and the fruit commonly a one-seeded utricle.

Ex. Paronychia and Anychia. Spergula has conspicuous petals, and many-seeded capsules; and so differs from Alsineæ only in its stipules. A small order of insignificant plants, of no economical account.

ORDER 23. PORTULACACEÆ. Succulent or fleshy herbs, with alternate or opposite entire leaves, destitute of proper stipules, and usually ephemeral flowers.—Calyx

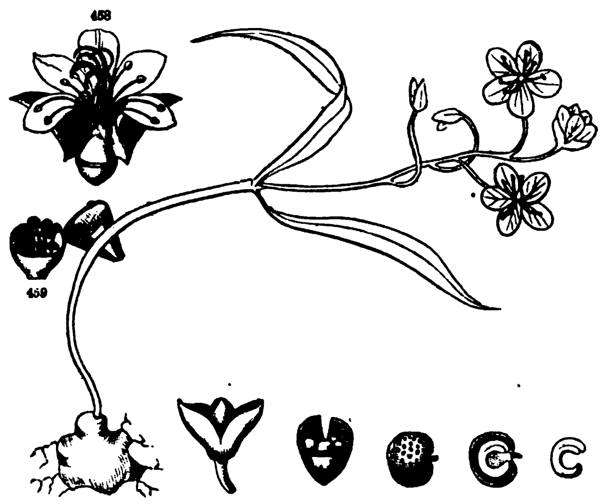


FIG. 452. Claytonia Virginica (Spring Beauty). 453. Young fruit and the persistent two-leaved calyx. 454. Section of the dehiscing capsule. 455. A seed. 456. The same vertically divided. 457. The embryo detached.

FIG. 458. Flower of the Purslane; the calyx cut away at the point where it adheres to the ovary, and laid open. 459. A capsule (pyxis, 428) of the same, transversely dehiscent.

mostly of two or three sepals, cohering with the base of the ovary. Petals five, or rarely more numerous. Stamens variable in number, but when equal to the petals situated opposite them. Styles two to eight, united below. Capsule with few or numerous seeds, attached to a central basilar placenta, often by slender funiculi (Fig. 459).

Ex. Portulaca (Purslane), Claytonia (Fig. 452). Chiefly natives of dry and arid places in the warmer parts of the world; except Claytonia. Insipid or slightly bitter: several are used as pot-herbs, as the Purslane. Some are ornamental. The farinaceous root of Lewisia rediviva, a native of dry plains in the interior of Oregon, is an important article of food with the natives of that desert region.

ORDER 24. MESEMBRYANTHEMACEÆ. Consists of a single genus of succulent plants, with showy flowers opening only under bright sunshine, containing an indefinite number of petals and stamens, and a many-celled and many-seeded capsule. The thickened leaves are often oddly shaped.

Ex. Mesembryanthemum (Fig-Marigold, Ice-plant); the numerous species are chiefly natives of the Cape of Good Hope, flourishing in the most arid situations.

Group 6. *Ovary compound and several-celled, with the placentæ in the axis, free from the calyx; sometimes with several or numerous ovaries, separate, or else more or less coherent, either directly or by means of a central axis. Calyx valvate in æstivation. Petals convolute or twisted in æstivation. Stamens indefinite, monadelphous, or somewhat polyadelphous, inserted with the petals (with which they frequently cohere) into the receptacle or base of the calyx. Embryo usually curved, the foliaceous cotyledons twisted and folded.*

ORDER 25. MALVACEÆ. Herbs, shrubs, or rarely trees. Leaves alternate, palmately veined, furnished with stipules. Flowers regular, generally showy, often with an

involucel, forming a double calyx.—Calyx mostly of five sepals, more or less united at the base. Petals as many as the sepals, twisted in æstivation. Stamens monadelphous: anthers reniform, one-celled. Styles as many as the carpels, distinct or united below. Fruit capsular, or the carpels separate or separable. Seeds with little albumen.

Ex. Malva (Mallows), Althæa (Hollyhock), Gossypium (Cotton), &c.: a pretty large and important family. Mal-

462 461 460 464 465 466 463

vaceous plants commonly abound in mucilage, and are entirely destitute of unwholesome qualities. The unripe fruit of Hibiscus esculentus (Okra) is used as an ingredient in soups. Althæa officinalis is the Marsh Mallow of Europe, the Guimauve of the French. The tenacious inner bark of many species is employed for cordage. Cotton is the hairy covering of the seeds of Gossypium: the long and slender tubes, or attenuated cells, collapse and twist spirally as the seed ripens, which renders the substance capable of being spun. Cotton-seed yields a fixed oil in large quantity, which may be used for lamps, &c.—Numerous species are cultivated for ornament.

FIG. 460. The Marsh Mallow (Althæa officinalis). 461. One of the kidney-shaped one-celled anthers, magnified. 462. The pistils, magnified. 463. Capsule of Hibiscus Moscheutos, with the persistent calyx and involucel. 464. The same loculicidally dehiscent. 465. A seed of Sida. 466. Embryo of the same, with the bent and folded cotyledons.

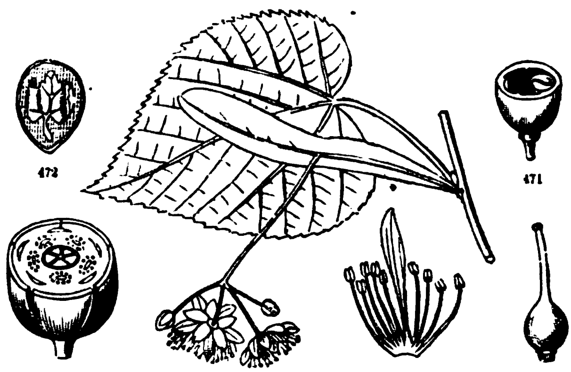
ORDER 26. TILIACEÆ. Trees or shrubby plants, with alternate leaves, furnished with deciduous stipules, and small flowers.—Calyx of three to five deciduous sepals. Petals three to five. Disk glandular. Stamens often in three to five clusters, distinct or somewhat united, one of each parcel often transformed into a petaloid scale: anthers two-celled. Styles united into one. Fruit two to five-celled, or, by obliteration, one-celled when ripe. Seeds

---

ORDER STERCULIACEÆ, very closely allied to Malvaceæ, and consisting of tropical trees, possesses the same mucilaginous properties (as well as oily seeds), with which bitter and astringent qualities are often combined. The seeds of Bombax, the Silk-cotton tree, are enveloped in a kind of cotton, which belongs to the endocarp and not to the seed; and the hairs, being perfectly smooth and even, cannot be spun. Canoes are made from the trunk of Bombax, in the West Indies, capable of carrying fifteen to twenty hogsheads of sugar, weighing from six to twelve hundred pounds each. To this order belongs the famous Baobab, or Monkeys'-bread of Senegal (Adansonia digitata); some trunks of which are from sixty to eighty feet in circumference! The fruit resembles a gourd, and serves for vessels; it contains a subacid and refrigerant, somewhat astringent, pulp; the mucilaginous young leaves are also used for food in time of scarcity; the dried and powdered leaves (*Lalo*), are ordinarily mixed with food, and the bark furnishes a coarse thread, which is made into cordage or woven into cloth. Cheirostemon platanoides is the remarkable Hand-flower tree of Mexico.

ORDER BYTTNERIACEÆ is another tropical and Australian family, nearly allied to Malvaceæ and Sterculiaceæ, and with the same general properties. *Chocolate* is made of the roasted and comminuted seeds of Theobroma Cacao (a South American tree), mixed with sugar, arnotto, vanilla, and other ingredients, and pressed into cakes. The roasted integuments of the seeds, also, are used as a substitute for coffee.

albuminous, with a large embryo; the foliaceous cotyledons usually folded or crumpled.



Ex. Tilia, the Linden, or Lime-tree (Fig. 467), represents the order in northern temperate regions; the other

---

ORDER DIPTEROCARPEÆ, intermediate in some respects between Tiliaceæ and Ternstrœmiaceæ, consists of a few tropical Indian trees, with a resinous or balsamic juice. Dryobalanops aromatica, a large tree of Sumatra and Borneo, yields in great abundance both a *camphor oil* and solid *camphor:* both are found deposited in cavities of the trunk, the latter frequently in pieces as long as a man's arm, weighing ten or twelve pounds. It is more solid than common camphor, and is not volatile at ordinary temperatures. It bears a high price, and is seldom found in Europe or this country, but is chiefly carried to China and Japan. A thin balsam, called *wood-oil* in India, and used for painting ships and

FIG. 467. Flowering branch of Tilia Americana, the common American Linden; the flower-stalk cohering with the bract (277). 468. Cross section of the unexpanded flower-bud, showing the valvate æstivation of the calyx (330), &c. 469. One of the clusters of stamens adhering to the *staminodium*, or petaloid scale. 470. The pistil. 471. Cross section of the fruit, which has become one-celled by the obliteration of the partitions seen in 468, and one-seeded. 472. Vertical section of the seed, magnified, to show the large embryo with its taper radicle and foliaceous crumpled cotyledons.

genera are tropical. All are mucilaginous, with a tough, fibrous inner bark. From this *bast* or *bass* of the Linden, the Russian mats, &c., are made, whence the name of Bass-wood. Gunny-bags and fishing-nets are made in India from the bark of Corchorus capsularis. The light wood of the Linden is excellent for wainscoting and carving: its charcoal is used for the manufacture of gunpowder. It is said that a little sugar may be obtained from the sap: and the honey made from the odorous flowers is thought to be the finest in the world. The acid berries of Grewia sapida are employed in the East in the manufacture of sherbet.

Group 7. *Ovary compound, with two or more cells and the placentæ in the axis, free from the calyx, which is imbricated in æstivation. Stamens indefinite or twice as many as the petals, frequently monadelphous, or polyadelphous at the base, inserted with the petals into the receptacle. Fruit a capsule, drupe, or a kind of berry (orange). Seeds destitute of albumen. Embryo mostly straight, with large or thickened cotyledons. — Trees or shrubs.*

ORDER 27. TERNSTRŒMIACEÆ. Trees or shrubs, with a watery juice, alternate simple leaves without stipules, and large and showy flowers. — Calyx of three to seven coriaceous and concave imbricated sepals. Petals five or more. Stamens indefinite, monadelphous or polyadelphous at the base. Capsule several-celled, usually with a central column. Seeds few in each cell, large, commonly with no albumen.

Ex. Gordonia (Loblolly Bay), Stuartia, Thea (Tea), Camellia. Ornamental plants, natives of tropical America,

---

houses, is yielded by some species of Dipterocarpus and Shorea. Shorea robusta yields the *Dammer-pitch*. Vateria Indica exudes a kind of copal, the *Gum Animi* of commerce; and a somewhat aromatic fatty matter, called *Piney Tallow*, is derived from the seeds.

except two genera in the Southern United States, and of Eastern Asia. The leaves of *Tea* contain a peculiar extractive matter, and a somewhat stimulant ethereal oil.

ORDER 28. AURANTIACEÆ. Trees or shrubs, with alternate leaves (compound, or with jointed petioles), destitute of stipules, dotted with pellucid glands full of volatile oil. Flowers fragrant. — Calyx short, urceolate or campanulate. Petals three to five. Stamens inserted in a single row upon a hypogynous disk, often somewhat monadelphous or polyadelphous. Style cylindrical: stigma thickish. Fruit a many-celled berry, with a leathery rind, filled with pulp. Seeds without albumen.

Ex. Citrus, the Orange and Lemon. Nearly all natives of tropical Asia; now dispersed throughout the warmer regions of the world; and cultivated for their beauty and fragrance, and for their grateful fruit. The acid of the Lemon, &c., is the Citric and Malic. The rind abounds in a volatile oil (such as the *Oil of Bergamot* from the Lime), and an aromatic, bitter principle.

ORDER 29. MELIACEÆ. Trees or shrubs, with alternate, usually compound leaves, destitute of stipules. — Calyx of three to five sepals. Petals three to five. Stamens twice as many as the petals, monadelphous, inserted with the petals on the outside of a hypogynous disk; the anthers included in the tube of filaments. Ovary several-celled, with one or two ovules in each cell: styles and stigmas united into one. Fruit a drupe, berry, or capsule; the cells one-seeded. Seeds without albumen, wingless.

Ex. Melia Azedarach (Pride of India), naturalized, as an ornamental tree, in the Southern States. An acrid and bitter principle pervades this tropical order.

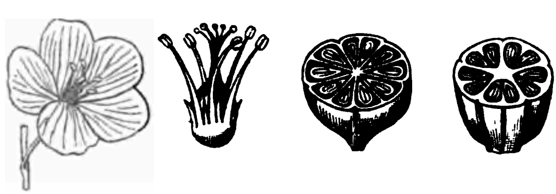
ORDER 30. CEDRELACEÆ. Trees (tropical or Australian), with hard and durable, usually fragrant and beautifully veined, wood; differing botanically from Meliaceæ

chiefly by their capsular fruit; with several winged seeds in each cell.

Ex. The *Mahogany* (Swietenia Mahogani) of tropical America, reaching to Southern Florida. The *Red-wood* of Coromandel is the timber of Soymida febrifuga; the *Satin-wood*, of Chloroxylon Swietenia of India; *Yellow-wood*, of the Australian Oxleya xanthoxyla, &c. All the species are bitter, astringent, tonic, often aromatic and febrifugal.

Group 8. *Ovary compound, or of several carpels adhering to a central axis, with one or more ovules in each cell or carpel, free from the calyx, which is mostly imbricated in æstivation. Petals as many as the sepals, or sometimes fewer. Stamens usually as many or twice as many as the petals, inserted on the receptacle, mostly monadelphous at the base. Seeds usually with little or no albumen. — Flowers perfect.*

Order 31. LINACEÆ. Herbs, with entire and sessile leaves, either alternate, opposite, or verticillate, and no stipules. Flowers regular and symmetrical. — Calyx of three to five persistent sepals, strongly imbricated. Petals as many as the sepals, twisted, with claws, ephemeral. Stamens as many as the petals, and often with intermediate teeth representing an abortive series, all united at the base into a ring. Ovary with as many styles and cells as there



472 473 475 474

FIG. 472. Flower of Linum perenne. 473. Its stamens and pistils. 474. Cross section of its capsule, showing the incomplete false partition from the back of each cell. 475. Section of the fruit of the common Flax, where the false partitions completely divide each proper cell into two.

are sepals, each cell with two suspended ovules; the cells in the capsule each more or less perfectly divided into two, by a false partition which grows from the back (dorsal suture); the spurious cells one-seeded. Embryo flat, fleshy and oily, with no albumen.

Ex. Linum, the Flax (Fig. 472 – 475), is the principal representative of this small family. The tough woody fibre of the bark (*flax*) is of the highest importance: the integuments of the seeds yield a copious mucilage, and the fixed oil expressed from the seeds is applied to various uses in the arts. The flowers are commonly handsome.

ORDER 32. GERANIACEÆ. Herbs or shrubby plants, commonly strong-scented; with palmately veined and usually lobed leaves, mostly with stipules; the lower opposite. Flowers regular, or somewhat irregular. — Calyx of five persistent sepals. Petals five, with claws, twisted in æsti-

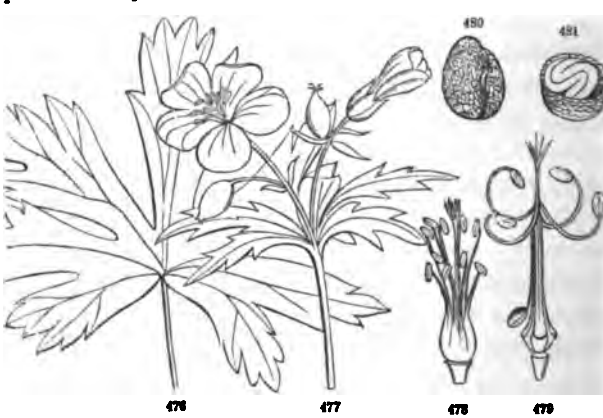


FIG. 476. Radical leaf of Geranium maculatum (Cranesbill). 477. A flowering branch. 478. A flower with the calyx and corolla removed, showing the stamens, &c. 479. The pistil in fruit; the indurated styles separating below from the prolonged axis, and curving back elastically, carrying with them the membranous carpels. 480. A magnified seed. 481. A cross-section of the same, showing the folded and convolute cotyledons.

vation. Stamens usually twice as many as the petals, some of them occasionally sterile; the filaments all broad and united at the base. Ovary of five two-ovuled carpels, attached to the base of an elongated axis (*gynobase*) to which the styles cohere: in fruit the distinct one-seeded carpels separate from the axis, by the twisting or curling back of the persistent indurated styles from the base upwards. Seeds with no albumen: cotyledons convolute and plaited.

Ex. Geranium (Fig. 476–481), or Cranesbill. Our cultivated Geraniums from the Cape of Good Hope are species of Pelargonium. The roots are simply and strongly astringent. The foliage abounds with an aromatic resinous matter and an etherial oil.

Order 33. OXALIDACEÆ. Low herbs, with an acid juice, and alternate compound leaves; the leaflets usually obcordate. Flowers regular.—Calyx of five persistent sepals. Petals five, twisted in æstivation. Stamens ten; the filaments broad and somewhat united at the base. Carpels five, united into a compound ovary, with the styles distinct; in fruit forming a membranaceous five-lobed and five-celled capsule. Seeds with a fleshy covering, which bursts elastically when ripe, albuminous, with a straight embryo.

Ex. Oxalis, the Wood Sorrel. The herbage is sour, as the name denotes, and contains oxalic acid. The foliage is remarkably sensitive in some species. The tubers of some South American species (called Arracacha) filled with starch, have been substituted for potatoes.

Order 34. BALSAMINACEÆ. Annual herbs, with succulent stems filled with a watery juice. Leaves simple, without stipules.—Flowers very irregular and unsymmetrical: the deciduous sepals colored, five in number, but the two upper usually united into one; the lower one spurred. Petals four, or apparently only two, on account of the union of the two lateral ones on each side. Stamens five, more

or less connected above. Compound ovary five-celled: stigmas sessile. Capsule bursting elastically by five valves. Seeds several, without albumen, and with a straight embryo.

Ex. Impatiens, the Balsam, or Touch-me-not. The flowers are generally showy. Remarkable for the elastic force with which the capsule bursts in pieces, and expels the seeds (489).

ORDER 35. TROPÆOLACEÆ. Straggling or twining herbs, with a pungent watery juice, and peltate or palmate leaves. Flowers irregular. — Calyx of five colored, united sepals, the lower one spurred. Petals five; the two upper arising from the throat of the calyx, remote from the three lower, which are stalked. Stamens eight, unequal, distinct. Ovary three-lobed, composed of three united carpels; which separate from the common axis when ripe, are indehiscent, and one-seeded. Seed filling the cell, without albumen: cotyledons large, thick, and conslidated.

Ex. Tropæolum, the Garden Nasturtium, from South America, where there are a few other species, one of which bears edible tubers. They possess the same acrid principle and anti-scorbutic properties as the Cruciferæ. The unripe fruit of Tropæolum majus is pickled, and used as a substitute for capers.

ORDER 36. LIMNANTHACEÆ. Annual herbs, with somewhat of the acrid taste of Tropæolum, alternate pinnatifid leaves, and no stipules. Flowers regular. — Calyx of three to five persistent sepals, united at the base, valvate. Petals three to five. Stamens twice as many as the petals. Ovaries three to five, united by their styles, which are combined into one; in fruit forming fleshy achenia, the cell filled by the solitary exalbuminous seed. Cotyledons very large and thick.

Ex. Limnanthes of California, and Flœrkea of the United States: the former is cultivated for its showy flow-

ers: the latter is a small, inconspicuous plant, growing in shady marshes. A slight acridity confirms their relationship to the preceding order.

Group 9. *Ovary compound and two to several-celled, or the carpels several and more or less united by their styles, one or few-ovuled. Calyx free. Petals as many as the sepals, or rarely wanting. Stamens as many or twice as many as the petals, distinct, inserted on the receptacle or the base of the calyx. — Flowers frequently polygamous or diœcious, regular.*

ORDER 37. ZYGOPHYLLACEÆ. Herbs, shrubs, or trees, with articulated branches; the leaves opposite, mostly abruptly pinnate, not dotted, furnished with stipules. Flowers perfect. — Calyx of four or five sepals. Petals four or five, with claws. Stamens twice as many as the petals: filaments dilated at the base, or placed on the back of a scale, inserted on the receptacle. Ovary composed of four or five united carpels, surrounded by a disk or row of glands: the styles and stigmas united. Fruit four or five-coccous, or ten-coccous when the carpels are spuriously two-celled. Seeds few. Embryo with foliaceous cotyledons.

Ex. Zygophyllum, Guaiacum; belonging to the warmer extra-tropical regions. Kallstrœmia maxima, the only plant of the order in the United States, has probably been introduced. The trees and shrubs of the order are remarkable for their very hard and heavy wood, which contains a gum-

---

ORDER SIMARUBACEÆ, composed of a few tropical, and chiefly American, trees and shrubs, is of some importance in medicine. The wood abounds in an excessively bitter extractive principle, called *Quassine.* The Quassia-wood of the shops is derived from the Quassia amara of Surinam and Guiana, or more commonly, at least of late years, from Picræna excelsa of Jamaica. It has been used as a substitute for hops in the manufacture of beer.

resinous bitter and somewhat acrid principle. *Lignum Vitæ* is the wood of Guaiacum officinale of the West Indies; from it the *Gum Guaiacum* is obtained.

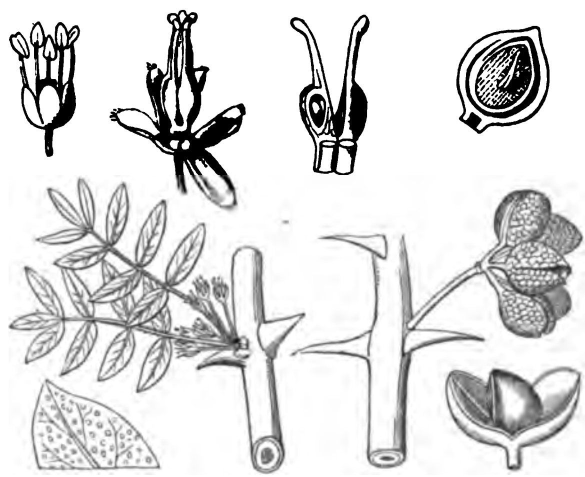
ORDER 38. RUTACEÆ. Herbs, shrubs, or trees; the leaves dotted and without stipules. Flowers perfect. Calyx of four or five sepals. Petals four or five. Stamens as many or two to three times as many as the petals, inserted on the outside of a cup-like disk. Ovary three to five-lobed, three to five-celled, with the styles united, or distinct only at the base, during ripening usually separating into its component carpels, which are dehiscent by one or both sutures. Seeds few.

Ex. Ruta (the Rue), Dictamnus (Fraxinella), of Europe, &c., and Diosma, of the Cape of Good Hope and New Holland. Remarkable for their strong and usually unpleasant order, and their bitterness (as in the common Rue of the gardens), owing to a volatile oil and a resinous matter, which is so abundantly exhaled by the Fraxinella in a hot, dry day, that it is said the air which surrounds it may be set on fire. Many plants of the Diosma tribe, especially those of Equinoctial America, contain a bitter alkaloid principle, and possess valuable febrifugal properties. The most important is the Galipea, which furnishes the *Angostura bark.*

ORDER 39. ZANTHOXYLACEÆ. Trees or shrubs; the leaves without stipules, and punctate with pellucid dots. Flowers polygamous or diœcious. — Calyx of three to nine sepals. Petals as many as the sepals, and convolute in æstivation, or wanting. Stamens as many or twice as many as the petals. Carpels two or more, borne on the convex or elevated receptacle, either united or separate, in the latter case the styles usually cohere when young. Seeds one or two in each cell or carpel, with a smooth and shining crustaceous testa.

Ex. Zanthoxylum (Prickly Ash) is the type of this order, of chiefly American, and nearly all tropical, plants. They are aromatic, pungent, stimulant, and bitter; these properties chiefly resident in the bark.

484 485 486 489



483 482 487 488

ORDER 40. ANACARDIACEÆ. Trees or shrubs, with a resinous or milky, often acrid, juice, which turns blackish in drying: the leaves alternate, without stipules, and not dotted. Flowers small, often polygamous or diœcious.— Calyx of three to five sepals, united at the base. Petals, and usually the stamens, as many as the sepals, inserted into the base of the calyx. Ovary one-celled, but with three styles or stigmas, and a single ovule. Fruit a berry or drupe. Seed without albumen.

FIG. 482. A flowering branch of Zanthoxylum Americanum (the Northern Prickly Ash). 483. A piece of a leaf, to show the pellucid dots. 484. Staminate flower. 485. A pistillate flower, the sepals spread open. (Petals none.) 486. Two of the pistils; one of them divided vertically to show the ovules. 487. A branch in fruit. 488. One of the dehiscent pods, and the seed. 489. Vertical section of an unripe pod and seed; the latter pendent from a descending funiculus, showing a slender embryo in copious albumen.

Ex. Rhus, Anacardium (the Cashew), Pistacia. Chiefly tropical; but several species of Rhus are indigenous to the United States. The acrid resinous juice is used in varnishes; but it often contains a caustic poison. Even the exhalations from Rhus Toxicodendron (Poison Oak, Poison Ivy), and R. venenata (Poison Sumach, Poison Elder), as is well known, severely affect many persons, producing erysipetalous swellings, &c. Their juice is a good indelible ink for marking linen. But the common Sumach (R. typhina and R. glabra) are wholly innocuous; their astringent bark is used for tanning; and their sour berries (which contain bimalate of lime) for acidulated drinks. The oily seeds of Pistacia vera (the Pistacia-nut) are edible. The drupe of Mangifera Indica (Mango) is the most grateful of tropical fruits. The seed of the Cashew-nut (Anacardium occidentale) is eatable; and so is the acid, enlarged, and

---

ORDER BURSERACEÆ, including a great part of what were formerly called Terebinthaceæ, consists of tropical trees, with a copious resinous juice, compound leaves usually marked with pellucid dots, and small, commonly perfect, flowers; with valvate petals, a two to five-celled ovary, and drupaceous fruit. Their balsamic juice, which flows copiously when the trunk is wounded, usually hardens into a resin. The *Olibanum*, used as a fragrant incense, the *Balm of Gilead*, or *Balsam of Mecca*, *Myrrh*, and the *Bdellium*, are derived from Arabian species of the order, the East Indian *Gum Elemi*, from Canarium commune; *Balsam of Acouchi*, and similar substances, from various American trees of this family.

ORDER AMYRIDACEÆ consists of a few West Indian plants, intermediate as it were between Burseraceæ and Leguminosæ, and distinguished from the former chiefly by their simple and solitary ovary. One species of Amyris grows in Florida. Their properties are the same as the preceding; the trunks abounding in a fragrant resinous juice.

fleshy peduncle on which the nut rests: but the coats of the latter are filled with a caustic oil, which blisters the skin; while from the bark of the tree a bland gum exudes.

Group 10. *Ovary compound, mostly two to three-lobed, two to three-celled, with one or two ovules in each cell, free from the calyx, which is imbricated in æstivation. Petals mostly irregular or one fewer than the sepals, sometimes wanting. Stamens distinct, definite, inserted on or around a hypogynous disk. Seeds destitute of albumen. Embryo curved, with large cotyledons.— Flowers frequently polygamous.*

Order 41. ACERACEÆ. Trees or shrubs, with opposite leaves and no stipules. Flowers small, regular, some-

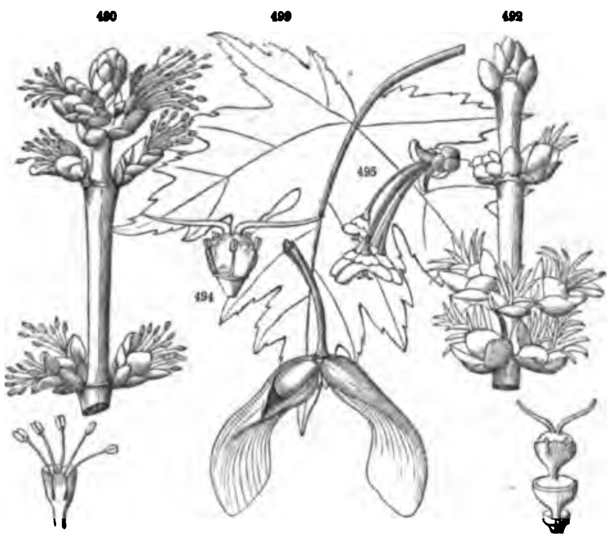


FIG. 490. A branch of Acer dasycarpum (the White Soft Maple) with staminate flowers. 491. A separate, enlarged staminate flower. 492. Branch with pistillate flowers. 493. A separate fertile flower; the bracts, &c., of the cluster cut away. 494. The same enlarged, with the calyx cut away. 495. A cluster showing the fruiting ovaries expanding into wings (reduced in size). 498. Ripe fruit; one of the samaras cut open to show the seed. 499. A leaf.

times perfect, in racemes, corymbs, or fascicles, often preceding the leaves. — Calyx mostly of five sepals, more or less united. Petals as many as the sepals, or none. Stamens three to twelve, seldom agreeing in number with the sepals. Ovary of two more or less united carpels; each carpel forming a samara in fruit.

Ex. Acer, the Maple; useful timber-trees of northern temperate regions. Sugar is yielded by the vernal sap of Acer saccharinum, and in less quantity by A. dasycarpum and other species.

ORDER 42. HIPPOCASTANACEÆ. Trees or shrubs; with opposite digitate leaves, without stipules; and showy,

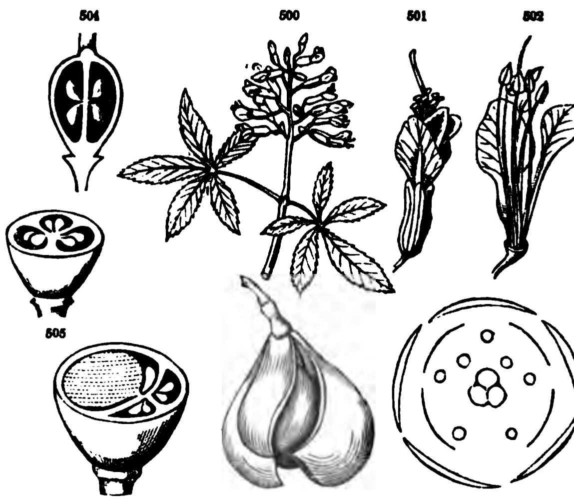


FIG. 500. Flowering branch of Æsculus Pavia, a species of Buckeye. 501. A flower. 502. Flower with the calyx and two of the petals removed. 503. A ground-plan of the flower, showing that its parts are unsymmetrical. 504. Vertical section of an ovary, showing two of the cells with a pair of ovules in each, one ascending, one descending. 505. Cross section of an ovary. 506. Cross section of the immature fruit; only one fertile seed; the others abortive. 507. The dehiscent fruit.

unsymmetrical, and perfect flowers, in large panicles or racemes. — Calyx of five united sepals. Petals usually four, sometimes five, irregular. Stamens seven or eight, unequal. Ovary three-celled; the styles united into one. Fruit roundish, coriaceous, dehiscent, with one to three very large seeds, resembling chestnuts. Embryo very large and fleshy, showing a two-leaved plumule.

Ex. Æsculus, the Horse-Chestnut, and Buckeye: fine ornamental trees. The large, starchy seeds are nutritious, but they contain a bitter principle which is more or less noxious. Those of Æ. Pavia are used to stupify fish. The root of the same species, according to Elliott, is employed as a substitute for soap.

ORDER 43. SAPINDACEÆ. Trees, shrubs, or climbers, with tendrils, rarely herbs (nearly all tropical and American); with alternate and mostly compound leaves. Flowers small, unsymmetrical, usually polygamous. — Calyx of four or five sepals. Petals irregular and often one fewer than the sepals, sometimes wanting. Stamens eight to ten. Ovary two or three-celled; the styles or stigmas more or less united. Seeds usually with an aril.

Ex. Sapindus (Soapberry, one species of which is indigenous to the southern borders of the United States); and Cardiospermum, which is a climbing herb, with a bladdery capsule, often met with in gardens. They are astringent and bitter. The fruit of Sapindus is used for soap.

Group 11. *Ovary compound, two to five-celled, free from, or adherent to, the calyx. Petals and stamens as many as the lobes of the calyx and inserted into its base or throat, or into the disk which covers it. Seeds albuminous, with a large and straight embryo. — Shrubs or trees. Flowers perfect or polygamous.*

ORDER 44. CELASTRACEÆ. Shrubs or trees, with alternate or opposite leaves. Calyx of four or five sepals,

imbricated in æstivation. Petals as many as the sepals, inserted under the flat expanded disk which closely surrounds the ovary. Stamens as many as the petals, and alternate with them, inserted on the margin or upper surface of the disk. Ovary free from the calyx. Fruit a capsule or berry, with one or few seeds in each cell. Seeds usually arilled.

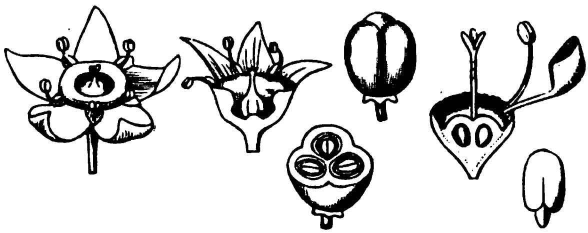
Ex. Celastrus (False Bitter-sweet), Euonymus (Burning Bush, Spindle-tree): these belong to Celastraceæ proper, which have simple leaves and arilled seeds. Staphylea (Bladder-nut) is the type of the suborder STAPHYLEACEÆ; which has compound leaves, and seeds with a bony testa, with no aril. They are all somewhat bitter and acrid; but of little economical importance. The crimson capsules and bright scarlet arils of Euonymus atropurpureus and E. Americanus (sometimes called Strawberry-tree), present a striking appearance when the fruit is ripe.

ORDER 45. RHAMNACEÆ. Shrubs or trees, often with spinose branches; the leaves mostly alternate, simple. Flowers small. — Calyx of four or five sepals, united at the base, valvate in æstivation. Petals four or five, cucullate or convolute, inserted on the throat of the calyx, sometimes wanting. Stamens as many as the petals, and opposite them! Ovary usually coherent with the tube of the calyx, and more or less immersed in a fleshy disk, with a single erect ovule in each cell. Fruit a capsule, berry, or drupe. Seeds not arilled.

Ex. Rhamnus (Buckthorn) is the type of the order. Ceanothus is peculiar to North America; just as some genera are to the Cape, and others to New Holland. The berries of most species of Rhamnus are somewhat nauseous; but those of Zizyphus are edible. The genuine *Jujube paste* is prepared from those of Z. Jujuba and Z. vulgaris of Asia. *Syrup of Buckthorn* is prepared from the fruit of

Rhamnus catharticus. The herbage and bark in this order are more or less astringent and bitter. An infusion of the

508 509 510 513



511 512

leaves of Ceanothus Americanus (thence called New Jersey Tea) was used as a substitute for tea in this country during the Revolutionary War; and a plant of the same order, Sageretia theæzans, is said to be used for the same purpose by the poorer classes in China.

ORDER 46. VITACEÆ. Shrubby plants climbing by tendrils, with simple or compound leaves, the upper alternate. Flowers small, often polygamous or diœcious.— Calyx very small, entire or four or five-toothed, lined with a perigynous disk. Petals four or five, inserted upon the outside of the disk, valvate in æstivation, sometimes cohering by their tips, caducous. Stamens as many as the petals, and opposite them! Ovary two-celled, with two erect ovules in each cell. Fruit a berry. Seeds with a bony testa.

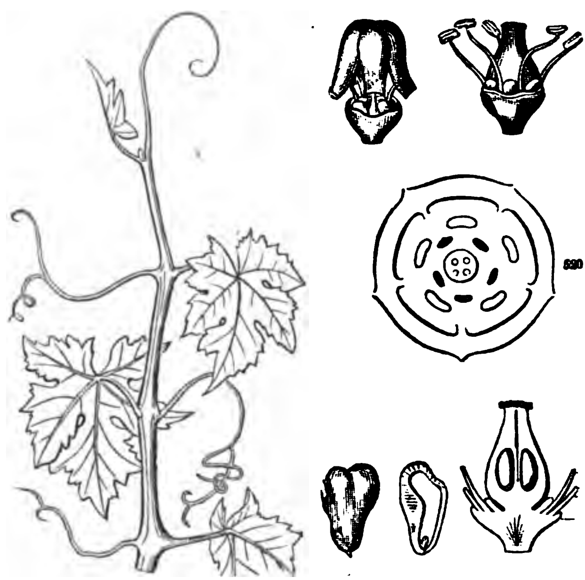
Ex. Vitis (the Grape), Ampelopsis (the Virginia Creeper.) The fruit of the Vine is the only important product of

FIG. 508. Flower of Rhamnus alnifolius. 509. Vertical section of the same, showing the structure of the perigynous disk, &c. 510. The drupaceous tricarpellary fruit. 511. Cross section of the same, through the cotyledons of the solitary seed in each cell. 512. The embryo detached.

FIG. 513. Section through the flower of Ceanothus Americanus, from which the (hooded and clawed) petals and stamens, all but one of each, have fallen away; showing the calyx adherent to the ovary below by means of the disk, and the solitary ovule in each cell.

the order. The acid of the grape, which also pervades the young shoots and leaves, is chiefly the tartaric. Grape sugar is very distinct from cane sugar, and the only kind that can long exist in connection with acids.

515 516



514 518 519 517

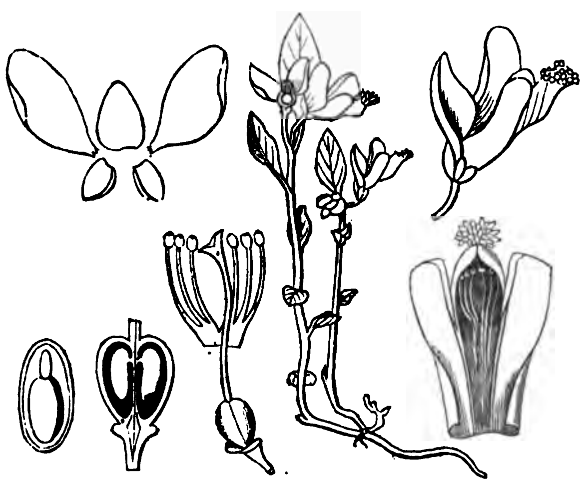
Group 12. *Character same as of the following order.*

ORDER 47. POLYGALACEÆ. Herbs or shrubby plants, with simple entire leaves, destitute of stipules; the

FIG. 514. A branch of the Grape; showing the nature of the tendrils (278). 515. A flower; the petals separating from the base, and falling off together without expanding. 516. A flower from which the petals have fallen; the lobes of the disk seen alternate with the stamens. 517. Vertical section through the ovary and the base of the flower: *a*, calyx, the limb of which is a mere rim: *b*, petal; having the stamen, *c*, directly before it; and the disk is shown between this and the ovary. 518. A seed. 519. Section of the seed; showing the thick crustaceous testa, and the albumen, at the base of which is the minute embryo. 520. A horizontal plan of the flower.

roots sometimes with a milky juice. Pedicels with three bracts. Flowers perfect, unsymmetrical. — Calyx of five irregular sepals; the two inner (*wings*) larger and usually petaloid. Petals usually three, inserted on the receptacle, more or less united; the anterior (*keel*) larger than the rest. Stamens six to eight, combined in a tube, which is split on the upper side, and united below with the claws of the petals: anthers innate, mostly one-celled, opening by a pore at the apex. Ovary compound, two-celled, with a single suspended ovule in each cell: style curved and often hooded. Capsule flattened. Seeds usually with a caruncle. Embryo straight, in fleshy albumen.

523 522



5 526 525 521 524

Ex. Polygala, the type of the order, is dispersed nearly throughout the world. Krameria, having only three or four

FIG. 521. Polygala paucifolia. 522. A flower enlarged. 523. The calyx displayed. 524. The corolla and stamineal tube laid open. 525. The pistil and the free portion of the stamens. 526. Vertical section of the ovary. 527. Vertical section of the seed, showing the large embryo and scanty albumen.

stamens, two-celled anthers, an indehiscent globose ovary which is one-celled and one-seeded by obliteration, and a somewhat different structure of the flower, has been separated as a suborder. A bitter principle pervades the order; and many species of Polygala also yield a peculiar acrid extractive matter. The Polygala Senega (Seneca Snake-root) is the most important medicinal plant of the family. Many other species are employed medicinally in Brazil, Peru, Nepaul, &c.; where, like our own, they are reputed antidotes to the bites of venomous reptiles.

Group 13. *Character same as of the following order.*

ORDER 48. LEGUMINOSÆ. Herbs, shrubs, or trees;

FIG. 530. Lathyrus myrtifolius. 531. The corolla displayed: *a*, the vexillum or standard; *b*, the alæ or wings; *c*, the two petals of the carina or keel. 532. The keel-petals in their natural situation. 533. The stamens and pistil, enlarged; the sheath of filaments partly turned back.

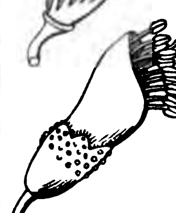

528 529

with alternate and usually compound leaves, furnished with stipules. Calyx mostly of five sepals, more or less united. Corolla of five petals, either papilionaceous or regular. Ovary single and simple. Fruit a legume. Seeds destitute of albumen. — This immense family is divided into two principal suborders; namely: —

1. Papilionaceæ. Corolla papilionaceous (313), or rarely almost regular, with an imbricated (vexillary, 329) æstivation, inserted upon the base of the calyx. Stamens ten, diadelphous (Fig. 528), sometimes monadelphous (Fig. 529),

535 538



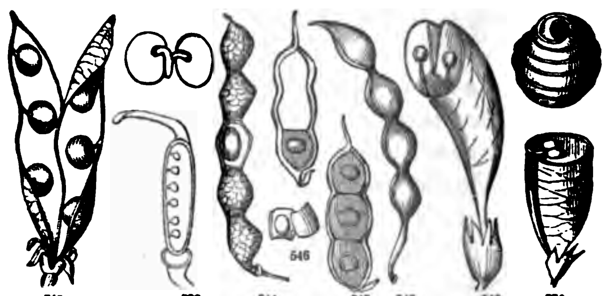

534 536 537

or distinct (Fig. 536), inserted with the petals. — *Ex.* Phaseolus (the Bean), Pisum (the Pea), Lathyrus (Fig. 32), the Locust, Clover, &c.

FIG. 534. Baptisia perfoliata. 535. A flower. 536. Same with the petals removed. 537. Flower of Amorpha, the corolla reduced to one petal. 538. Its stamens and pistil.

2. Mimoseæ. Calyx and corolla regular, usually valvate in æstivation. Stamens definite (four or five to twenty), or very numerous, usually distinct and inserted on the receptacle. — *Ex.* Mimosa, Acacia, Inga.

Papilionaceæ are found in every part of the world, from the tropics to the frigid zones: Mimoseæ are confined to the tropical and warmer temperate regions. — A full account of



the useful plants and products of this large order would require a separate volume. Many, such as Clover, Lucerne (Medicago sativa), &c., are extensively cultivated for fodder; Peas and Beans for pulse. The roots of the Licorice (Glycirrhiza glabra of Southern Europe), abound in a sweet mucilaginous juice, from which the pectoral extract of this name is prepared. The sweet pulp of the pods of Ceratonia Siliqua (Carob-tree of the South of Europe, &c.), of the Honey-Locust (Gleditschia), &c., is likewise eaten. The laxative pulp of Cathartocarpus Fistula, and of the Tama-

FIG. 539. Pistil of the common Pea, the ovary divided vertically. 540. Open legume of the same. 541. The embryo; the cotyledons laid open. 544. A jointed legume (loment) of Desmodium. 545. Loment of Mimosa. 546. One of the dehiscent joints, which has fallen away from the persistent border, 547, or replum. 548. The jointed torose legume of Sophora. 549. Legume of an Astragalus, transversely divided; the dorsal suture introflexed, so as almost to reach the ventral. 550. Section of the legume of Phaca; the ventral suture inflexed. 551. Legume of Medicago lupulina.

rind, is well known; the latter is acidulated with malic, and a little tartaric and citric acids. — A peculiar volatile principle (called *coumarin*) gives its fragrance to the well known *Tonka-bean* and the Melilotus, or Sweet Clover; the flowers and seeds of which are employed to give the peculiar odor to *Gruyère* or *Scheipzeiger* cheese. — Astringents and tonics are also yielded by this order: such as the African Pterocarpus erinaceus, the hardened red juice of which is *Gum Kino;* that of P. Draco, of Carthagena, &c., is *Dragon's Blood.* The bark of most Acacias and Mimosas contain a very large quantity of tannin, and are likely to prove of great importance in tanning. The valuable astringent called *Catechu* is obtained by boiling and evaporating the heartwood of the Indian Acacia Catechu. — Leguminosæ yield the most important coloring matters; such as the *Brazil-wood*, the *Logwood* of Campeachy (the peculiar coloring principle of which is called *Hæmatin*); and the *Red Sandal-wood* of Ceylon. The wood of our Cladrastis lutea yields a yellow coloring matter, which may possibly be turned to account. Most important of all is *Indigo*, which is prepared from the fermented juice of the Indigofera tinctoria (a native of India), and also from I. cærulea, and other species of the genus. This substance is a violent poison. — To the same order we are indebted for valuable resins and balsams; such as the Mexican *Copal*, *Balsam of Copaiva* of the West Indies, Para, and Brazil, the bitter and fragrant *Balsam of Peru*, and the sweet, fragrant, and stimulant *Balsam of Tolu.* — This rich order also furnishes the most useful gums; of which we need only mention *Gum Tragacanth*, derived from Astragalus verus of Persia, &c.; and *Gum Arabic*, the produce of numerous African species of Acacia. The best is said to be obtained from A. vera, which extends from Senegal to Egypt; while *Gum Senegal* is yielded by Acacia Verek, and some other species of the River Gambia. The

Senna of commerce consists of the leaves of several species of Cassia, of Egypt and Arabia. C. Marilandica of this country is a succedaneum for the officinal article. — More acrid, or even poisonous properties, are often met with in the order. The roots of Baptisia tinctoria (called Wild Indigo, because it is said to yield a little of that substance), of the Broom, and of the Dyers' Weed (Genista tinctoria, used for dying yellow) possess such qualities; while the seeds of Laburnum, &c., are even narcotico-acrid poisons. The branches and leaves of Tephrosia, and the bark of the root of Piscidia Erythriua (Jamaica Dogwood, which is also found in Southern Florida), are commonly used in the West Indies for stupefying fish. *Cowitch* is the stinging hairs of the pods of Mucuna pruriens of the West, and M. prurita of the East, Indies. — Among the numerous valuable timber-trees, our own Locust (Robinia Pseudacacia) must be mentioned; and also the Rose-wood of commerce, the produce of a Brazilian species of Mimosa. Few orders furnish so many plants cultivated for ornament.

Group 14. *Ovaries simple and distinct, or usually compound, and two to several-celled, with the placentæ in the axis. Calyx free from, or coherent with, the ovary. Petals regular, inserted on the throat of the calyx. Stamens distinct, inserted with the petals. Seeds destitute of albumen. Embryo straight.*

ORDER 49. ROSACEÆ. Trees, shrubs, or herbs, with alternate leaves, usually furnished with conspicuous stipules. Flowers commonly showy, regular. — Calyx of five (rarely three or four) more or less united sepals, and often with as many bracts. Petals as many as the sepals (rarely none), inserted on the edge of a thin disk that lines the tube of the calyx. Stamens indefinite or sometimes few, distinct. Ovaries with solitary or few ovules: styles often lateral. Embryo straight. — This important order is divided into four suborders; namely: —

1. Chrysobalaneæ. Ovary solitary, free from the calyx, or else cohering with it at the base on one side only, containing two erect ovules: style arising from the apparent base. Fruit a drupe.—Trees or shrubs. *Ex.* Chrysobalanus.

2. Amygdaleæ. Ovary solitary, free from the deciduous calyx, with two suspended ovules, and a terminal style. Fruit a drupe. *Ex.* Amygdalus (the Almond, Peach, &c.), Prunus (the Plum), Cerasus (the Cherry).—Trees or shrubs.


552


553

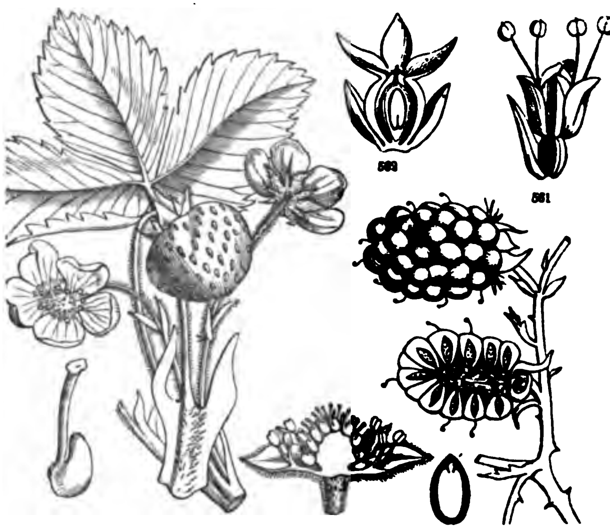

554

555

3. Rosaceæ proper. Ovaries several, numerous, or rarely solitary, free from the calyx (which is often bracteolate, as if double), but sometimes inclosed in its persistent tube, in fruit becoming either follicles or achenia. Styles terminal or lateral. Herbs or shrubs.—The three tribes of this suborder are, Tribe 1. Spireæ, where the fruit is a follicle. *Ex.* Spiræa and Gillenia. Tribe 2. Dryadeæ, where the fruits are achenia, or sometimes little drupes, and when numerous crowded on a conical or hemispherical torus. *Ex.* Dryas, Agrimonia, Potentilla, Fragaria (Strawberry), Rubus (Raspberry and Blackberry). Tribe 3. Roseæ, where numerous achenia cover the hollow torus which lines the urn-shaped calyx tube; and the latter, be-

FIG. 552. Fruit of the Almond; the exocarp dehiscent. 553. Vertical section of the drupe of the Peach. 554. Embryo of the Almond. 555. The same with one of the cotyledons cut away: *a*, the plumule.

ing contracted at the mouth, and becoming fleshy or berry-like, forms a kind of false pericarp; as in the Rose (417).

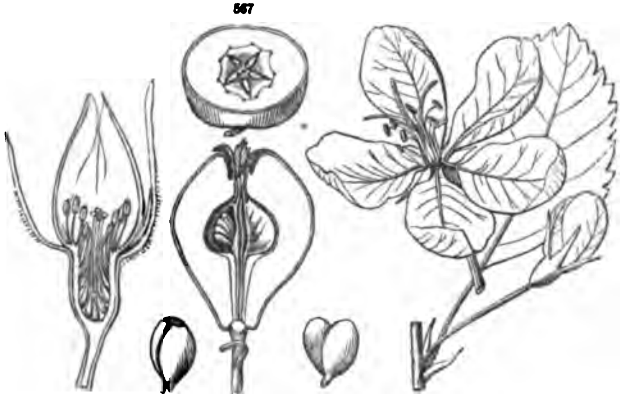


4. Pomeæ. Ovaries two to five, or rarely solitary, cohering with each other and with the thickened and fleshy or pulpy calyx-tube; each with one or few ascending seeds. — Trees or shrubs. *Ex.* Cratægus (the Thorn), Cydonia (the Quince), Pyrus (the Apple, Pear, &c.).

This important order is diffused through almost every

FIG. 556. The Strawberry (Fragaria). 557. Half of a flower, divided vertically, from which the petals are removed; showing the perigynous insertion of the stamens; and the enlarged receptacle, which, increasing in size, forms the pulpy, edible fruit, bearing the achenia, or real fruits, on its surface. 558. One of the carpels magnified, showing the lateral style. 559. Fruit of the Blackberry (Rubus villosus), with a longitudinal section: here the elongated receptacle does not enlarge, but the ovaries become drupes. 560. Section of the endocarp; the cavity of which is filled by the seed, and that by the embryo, with its large cotyledons. 561. A flower of Sanguisorba Canadensis, enlarged. 562. Vertical section of the same in fruit; the solitary ovary inclosed by, but not coherent with, the persistent calyx-tube; the single seed with its large embryo filling the achenium.

part of the world; but chiefly abounds in temperate climates; where it furnishes the most important fruits. It is



destitute of unwholesome qualities, with one or two exceptions; namely, 1st. The bark, leaves, and kernel of Amygdaleæ contain prussic acid, as is indicated by their peculiar odor; a trace of which is perceived in some species of Spiræa, and in the Mountain Ash, &c., among Pomeæ; and 2d. The root of Gillenia (Bowman's Root, Indian Physic), is emetic in large doses, but in small doses it acts as a tonic. The bark and root in all are astringent. The bark of Amygdaleæ also exudes gum. That of the Wild Black Cherry is a valuable febrifuge; and the timber is useful in cabinet work. The leaves of Cerasus Caroliniana contain so much prussic acid as to destroy cattle that feed upon them. It takes the place in this country of the Cerasus

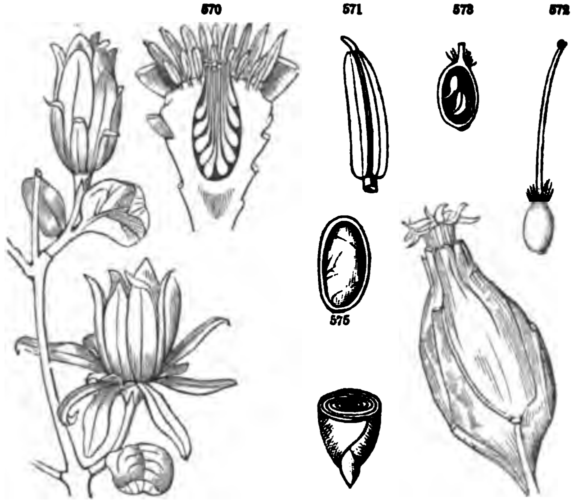
FIG. 563. Vertical section of an unexpanded Rose, showing the attachment of the carpels to the lining of the calyx-tube, and of the stamens and petals to its summit or edge. 564. Vertical section of the fruit of the Quince, exhibiting the carpels invested by the thickened calyx which forms the edible part of the fruit; one of the ovaries laid open to show the seeds. 565. A magnified seed; the raphe and chalaza conspicuous. 566. The embryo. 567. Cross section of an apple. 568. Flower, &c. of the American Crab-Apple (Pyrus coronaria).

Lauro-cerasus (Cherry-Laurel) of the old world, from which the poisonous *Laurel-water*, and the virulent *Oil of Laurel* is obtained. Sweet and Bitter Almonds are the seeds of varieties of Amygdalas communis (indigenous to the East), differing in the quantity of the prussic acid they contain: the oil of the former resembles olive-oil; that of the latter is a deadly poison. Of the Peach, Apricot, Nectarine, Plum, and Cherry, it is unnecessary to speak. The kernels, as well as the flowers of the former, especially abound in prussic acid. — The strawberry, raspberry, and blackberry are the principal fruits of the proper Rosaceæ. The leaves of Rosa centifolia are more commonly distilled for *Rose-water:* and *Attar of Roses* is obtained from R. damascena, &c. — Pomaceous fruits, such as the apple, pear, quince, services, medlar, &c., yield to none in importance: their acid is usually the malic.

ORDER 50. CALYCANTHACEÆ. Shrubs, with quadrangular stems (which when old exhibit four axes of growth exterior to the old wood), opposite entire leaves without stipules, and solitary, axillary and terminal, lurid flowers. — Calyx of numerous somewhat thickened colored sepals, in several rows, confounded with the petals, all united below into a fleshy tube or cup, bearing numerous stamens upon its rim. Outer stamens with adnate extrorse anthers: the inner sterile. Ovaries indefinite, two-ovuled, becoming hard achenia in fruit, inserted on the whole inner surface of the disk which lines the calyx-tube, in which they are inclosed as in the Rose. Cotyledons convolute.

Ex. This order (distinguished from Rosaceæ by the opposite leaves, the anthers turned outwards, the imbricated sepals, and the convolute cotyledons) consists of two genera; namely, Calycanthus (Carolina Allspice, Sweet-scented Shrub, &c.); and Chimonanthus, of Japan. They are cultivated for their fragrant flowers. The bark and foliage of

Calycanthus exhales a camphoric odor: and the flowers of some species, a fragrance not unlike that of strawberries.



Order 51. MYRTACEÆ. Trees or shrubs, with opposite and simple entire leaves, which are punctate with pellucid dots, and usually furnished with a vein running parallel with and close to the margin; without stipules. Calyx-tube adherent to the compound ovary; the limb four or five-cleft, valvate in æstivation. Petals four or five, or sometimes wanting. Stamens indefinite, usually with long filaments and small round (introrse) anthers. Style single. Seeds usually numerous.

Ex. Myrtus, the Myrtle, is the most familiar represent-

FIG. 569. Flowers of Calycanthus floridus. 570. Vertical section of a flower, showing the hollow receptacle, &c.; the floral envelopes cut away. 571. A stamen, seen from without. 572. A pistil. 573. Section of the ovary, showing the two ascending ovules. 574. The closed pod-shaped receptacle in fruit. 575. A vertical section of an achenium showing the embryo of the seed. 576. Cross section of an embryo, showing the finely convolute cotyledons.

ative of this beautiful tropical and subtropical order; which is well distinguished from its allies by its opposite dotted leaves and aromatic properties. The species abound in a pungent and aromatic volatile oil, and an astringent principle. *Cloves* are the dried flower-buds of Caryophyllus aromaticus. *Pimento* (Allspice) is the dried fruit of Eugenia Pimenta. *Cajeput oil*, a powerful sudorific, is distilled from the leaves and fruit of a Melaleuca of the Moluccas. Numerous Australian species of Eucalyptus, which compose a great part of the forests of that country, yield a large quantity of tannin. The aromatic fruits of many species, filled with sugar and mucilage, and acidulated with a free acid, are highly prized; such, for instance, as the Pomegranate, and the Guava, Rose-Apple, &c.

ORDER 52. MELASTOMACEÆ. Trees, shrubs, or herbs, with opposite ribbed leaves, and showy, usually purple, flowers, with as many or twice as many stamens as petals; the anthers mostly appendaged and opening by pores: further distinguished from Myrtaceæ by the leaves not being dotted; and from both that order and Lythraceæ, by the cohesion merely of the nerves of the calyx-tube with the angles of the ovary, and the æstivation of the stamens, which have their long anthers inflexed and received in the tubular intervening spaces.

Ex. The beautiful species of Rhexia represent this remarkable order in the United States: all the rest are tropical. The berries of Melastoma are eatable, and tinge the lips black, like whortleberries; whence the generic name.

ORDER 53. LYTHRACEÆ. Chiefly herbs, with angled or four-sided branches; the leaves opposite, verticillate, or alternate (even on the same plant), entire, not dotted, nor furnished with stipules. — Calyx tubular and persistent, inclosing the two to four-celled ovary, but entirely free from it! Petals deciduous, or sometimes wanting, inserted be-

tween the lobes of the calyx. Stamens definite, inserted below the petals. Styles perfectly united into one. Capsule membranaceous, often one-celled by the obliteration of the dissepiments.

Ex. Lythrum (Loosestrife), &c. Cuphea has irregular flowers. The greater part of this small order is tropical. The *Henné*, used by Oriental women to perfume and stain their hair and nails, is the juice of Lawsonia alba.

ORDER 54. ONAGRACEÆ. Herbs, or rarely shrubby plants, with alternate or opposite leaves, not dotted, nor furnished with stipules. Flowers usually showy, tetramerous. — Calyx adherent to the ovary, and usually produced beyond it into a tube. Petals usually four (rarely three or six, occasionally absent), and the stamens as many, or twice as

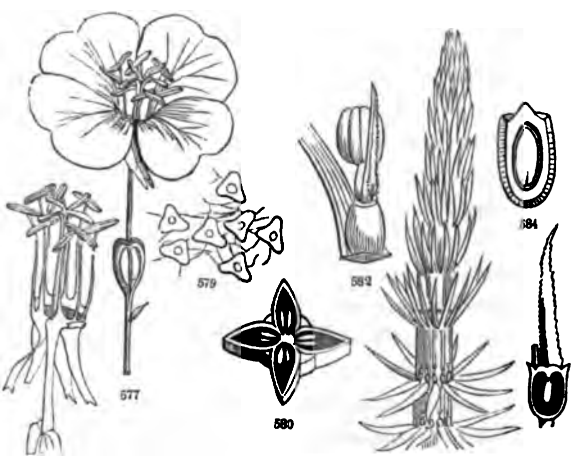


FIG. 577. Flower of Œnothera fruticosa. 578. The same, about the natural size, with the petals removed. 579. Magnified grains of pollen, with some of the intermixed cellular threads. 580. Cross section of the four-lobed and four-celled capsule.

FIG. 581. Hippuris vulgaris (suborder Halorageæ). 582. Magnified flower, with the subtending leaf. 583. Vertical section of the ovary. 584. Vertical section of the fruit and seed.

many, inserted into the throat of the calyx. Ovary commonly four-celled: styles united; the stigmas four, or united into one. Fruit mostly capsular.

Ex. Fuchsia, remarkable for its colored calyx and berried fruit; Œnothera (Evening Primrose); Epilobium, where the seeds bear a coma; Gaura, where the petals are often irregular; Ludwigia, which is sometimes apetalous; and Circæa, where the lobes of the calyx, petals, stamens, cells of the ovary, and the seeds, are reduced to two; showing a connection with the appended suborder,

Haloragéæ; which are a sort of reduced aquatic Onagraceæ, often apetalous; the solitary seeds furnished with a little albumen; as in Myriophyllum (Water Milfoil) and Hippuris (Horse-tail), where the limb of the calyx is almost wanting; the petals none, the stamens reduced to a single one, and the ovary to a single cell, with a solitary seed.

Widely diffused throughout America. Of no economical importance. The Evening Primroses, Fuchsias, &c., are showy plants in cultivation.

Order 55. COMBRETACEÆ consists of tropical trees or shrubs (which have one or two representatives in Southern Florida), often apetalous, but with slender colored stamens; distinguishable from any of the preceding orders of this group by their one-celled ovary, with several suspended ovules, but only a solitary seed, and convolute cotyledons.

Ex. Combretum. Some species cultivated for ornament; some are used by tanners. The seeds of Terminalia Catappa (which extends into Florida) are eaten like almonds.

Order 56. RHIZOPHORACEÆ consists of a few tropical trees (extending into Florida and Louisiana), growing in maritime swamps; with the ovary often partly free from the calyx, two-celled, with two pendulous ovules in each cell; they are remarkable for their opposite leaves,

with interpetiolar stipules, and for the germination of the embryo while within the pericarp (62, 445).

Ex. Rhizophora, the Mangrove (Fig. 64). The astringent bark has been used as a febrifuge, and for tanning.

Group 15. *Ovary compound, one-celled, with parietal placentæ. Calyx adherent to the ovary, or sometimes free. Petals and stamens inserted on the throat of the calyx (or in* Passiflora *on the stalk of the ovary). — Flowers perfect, except in* Papayaceæ.

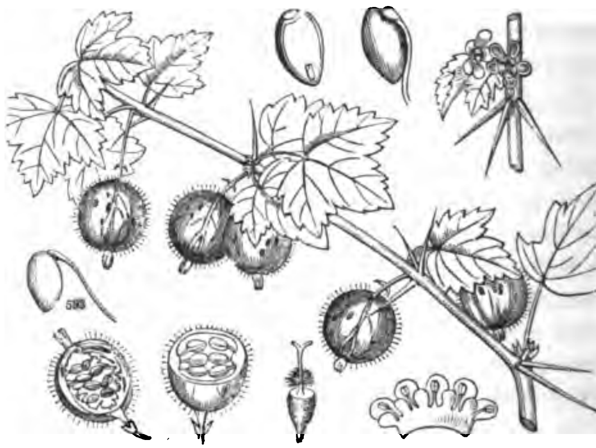
Order 57. LOASACEÆ. Herbs usually clothed with rigid or stinging hairs; the leaves opposite or alternate, without stipules; the flowers showy. — Calyx-tube hemispherical, clavate, or cylindrical, adherent to the ovary; the limb mostly five-parted. Petals as many, or twice as many, as the lobes of the calyx. Stamens indefinite and in several parcels, or sometimes definite. Style single. Ovary with three to five parietal placentæ. Seeds few or numerous, albuminous.

Ex. Loasa, Mentzelia, Cevallia; the latter with solitary seeds and no albumen. All American; in the United States nearly confined to the regions beyond the Mississippi. Of no known importance. The bristles of Loasa sting like nettles.

Order 58. CACTACEÆ. Succulent shrubby plants, peculiar in habit, with spinous buds, usually leafless; the stems either subglobose and many angled, columnar with several angles, or flattened and jointed. Flowers solitary, usually large and showy. — Calyx of numerous sepals, imbricated, coherent with and crowning the ovary, or covering its whole surface; the inner usually confounded with the indefinite petals. Stamens indefinite, with long filaments, cohering with the base of the petals. Styles united: stigmas and parietal placentæ several. Fruit a berry. Seeds numerous, with little or no albumen.

Ex. The Cactus family is all American, at least originally, and chiefly tropical. The common Opuntia (Prickly Pear) is the only representative in the Northern and Atlantic States. The mucilaginous fruit is eatable.

592 591 585



590 589 588 587 586

ORDER 59. GROSSULACEÆ. Small shrubs, either spiny or prickly, or unarmed; with alternate, palmately lobed and veined leaves, usually in fascicles, often sprinkled with resinous dots. Flowers in racemes or small clusters. — Calyx-tube adherent to the ovary, and more or less produced beyond it, five-lobed, sometimes colored. Petals five, small. Stamens five. Ovary with two parietal placentæ: styles more or less united. Fruit a many-seeded berry,

FIG. 585. The Gooseberry (Ribes Uva-crispa); a branch in flower. 586. Branch in fruit. 587. The calyx, bearing the petals and stamens, cut away from the summit of the ovary (588), and laid open. 589 and 590. Sections of the unripe fruit. 591. Magnified seed (anatropous). 593. The same from the ripe fruit, where the raphe separates from the side of the seed, and forms a part of the funiculus. 592. Longitudinal section of the same, showing the minute embryo at the extremity of the albumen.

crowned with the shrivelled remains of the flower. Embryo minute, in hard albumen.

Ex. Ribes (Gooseberry and Currant). Natives of temperate and colder regions, chiefly of the northern hemisphere. Never unwholesome: the fruit usually esculent, containing mucilaginous and saccharine pulp, with more or less malic or citric acid. Several Oregon and Californian species are showy in cultivation.

ORDER 60. TURNERACEÆ. Herbs, with the habit of Cistus or Helianthemum; the alternate leaves without stipules. Flowers solitary, showy. — Calyx five-lobed; the five petals and five stamens inserted on its throat. Ovary free from the calyx, with three parietal placentæ. Styles distinct, commonly branched or many-cleft at the summit. Fruit a three-valved capsule. Seeds numerous (anatropous), with a crustaceous and reticulated testa, and a membranaceous aril on one side. Embryo in fleshy albumen.

Ex. Turnera is the principal genus of this small and unimportant tropical American order, of which there is one species in Georgia.

ORDER 61. PASSIFLORACEÆ. Herbs, or somewhat shrubby plants, climbing by tendrils; with alternate, entire or palmately lobed leaves, mostly furnished with stipules. Flowers often showy, sometimes involucrate. — Calyx mostly of five sepals, united below, free from the ovary; the throat bearing five petals and a filamentous crown. Stamens as many as the sepals, monadelphous, and adhering to the stalk of the ovary, which has usually three club-shaped styles or stigmas, and as many parietal placentæ. Fruit mostly fleshy or berry-like. Seeds numerous, with a brittle sculptured testa, inclosed in pulp. Embryo inclosed in thin, fleshy albumen.

Ex. Passiflora (the Passion-flower, Granadilla): nearly all natives of tropical America. Two species are found

as far north as Virginia and Ohio. Many are cultivated for their singular and showy flowers. The acidulous refrigerant pulp of Passiflora quadrangularis (the Granadilla), P. edulis, and others, is eaten in the West Indies, &c. But the roots are emetic, narcotic, and poisonous. They contain a principle resembling morphine, which, in some species, extends even to the flowers and fruit.

ORDER 62. PAPAYACEÆ. Trees, with a simple cylindrical trunk, or generally thickened near the base, leafy only at the summit, every part yielding a slightly acrid milky juice; the leaves large, palmately lobed, on long petioles, without stipules. Flowers diœcious or monœcious, axillary.—Calyx minute, five-toothed. Corolla inserted on the receptacle, of five petals, which in the fertile flowers are distinct; but in the sterile united into a funnel-form five-lobed corolla. Stamens in the sterile flowers ten, inserted into the throat of the corolla; five nearly sessile opposite the segments, the others with evident filaments: mere rudiments in the fertile flowers. Ovary free, large, sessile, with five parietal placentæ, and crowned with as many lacerated stigmas. Fruit succulent, indehiscent: the placentæ bearing numerous seeds; which are covered with a wrinkled, loose aril, and enveloped in mucus. Embryo in fleshy albumen.

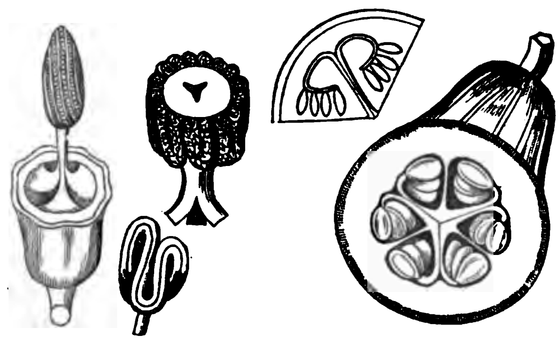
Ex. The Papaw-tree (Carica Papaya), a native, with some other species, of tropical America (reaching to Southern Florida), and cultivated throughout the tropics; where it attains the height of twenty feet or more in the space of three years. The fruit, when cooked, is eatable: but the juice of the unripe fruit, as well as of other parts of the plant, is a powerful vermifuge. The juice contains so much fibrine that it has an extraordinary resemblance to animal matter: meat washed in water impregnated with this juice is rendered tender; even the exhalations from the tree pro-

duce the same effect upon meat suspended among the leaves.

Group 16. — *Character same as of the following order.*

ORDER 63. CUCURBITACEÆ. Juicy herbs, climbing by tendrils; with alternate, palmately veined or lobed, rough leaves, and monœcious or diœcious flowers. — Calyx of four or five (rarely six) sepals, united into a tube, and in the fertile flowers adherent to the ovary. Petals as many as the sepals, commonly more or less united into a monopetalous corolla, which coheres with the calyx. Stamens five or three, inserted into the base of the corolla or calyx, either distinct or variously united by their filaments, and long, sinuous or contorted anthers. Ovary two to five-celled (rarely one-celled by obliteration, and even one-ovuled); the thick and fleshy placentæ often filling the cells, or carried back so as to reach the walls of the pericarp; the dissepiments often disappearing during its growth: stigmas thick, dilated or fringed. Fruit (pepo, 425) usually fleshy, with a hard

594 595 598



596 597

FIG. 594. Staminate flower of the Gourd; the calyx and corolla cut away. 595. Cross section of the united anthers. 596. Separate stamen of the Melon. 597. Section of the ovary of the Gourd. 598. Plan of one of the three constituent carpels.

34

rind, sometimes membranous. Seeds flat, often arilled, with no albumen. Cotyledons foliaceous.

Ex: The Pumpkin and Squash (Cucurbita), Gourd, Cucumber, and Melon. When the acrid principle which prevails throughout the order is greatly diffused, the fruits are eatable and sometimes delicious: when concentrated, as in the Bottle Gourd, Bryony, &c., they are dangerous or actively poisonous. The officinal *Colocynth*, a resinoid, bitter extract from the pulp of Cucumis Colocynthis (of the Levant, India, &c.), is very acrid and poisonous; and *Elaterium*, obtained from the juice of the Squirting Cucumber (Momordica Elaterium of the South of Europe), is still more violent in its effects. Momordica Balsamina (the cultivated Balsam-Apple) contains the same principle in smaller quantity. The seeds of all are harmless.

Group 17. *Ovaries two or more and distinct, or partly united; or combined into a compound pistil, which has two or more cells with the placentæ in the axis, or is sometimes one-celled with parietal placentæ. Calyx free from the ovary or more or less united with it. Stamens (mostly definite) and petals inserted on the calyx. Seeds several or numerous, with a straight embryo in the midst of albumen.*

ORDER 64. CRASSULACEÆ. Herbs, or slightly shrubby plants, mostly fleshy or succulent; with scattered leaves, and flowers usually in cymes or racemes. Calyx of three to twenty sepals, more or less united at the base, free from the ovaries, persistent. Petals as many as the sepals, rarely combined into a monopetalous corolla. Stamens as many or twice as many as the sepals. Pistils always as many as the sepals, distinct, or rarely (in Penthorum and Diamorpha) partly united: ovaries becoming follicles in fruit, several-seeded.

Ex. Sedum (Stone-crop, Orpine, Live-for-ever), Crassula (Fig. 176 – 184), Sempervivum, or House-Leek, &c.

Distinguished by their symmetrical flowers (296). These plants are remarkable for growing upon dry rocks in the most exposed and sun-burnt places; and are very tenacious of life.

ORDER 65. SAXIFRAGACEÆ. Herbs or shrubs, with alternate or opposite leaves. — Calyx of four or five more or less united sepals, either free from or more or less adherent to the ovary, persistent. Petals as many as the sepals, rarely wanting. Stamens as many, commonly twice as many, or rarely three or four times as many, as the sepals. Ovaries mostly two (sometimes three or four), usually united below and distinct at the summit. Seeds numerous. — There are four principal divisions, or suborders; namely: —

FIG. 599. Sullivantia Ohionis. 600. Flower with the calyx laid open, somewhat enlarged. 601. Fruit surrounded by the persistent calyx and withered petals, enlarged. 602. Section of the lower part of the capsule, magnified; showing the central placenta covered with the ascending seeds. 603. A magnified seed, with its cellular, wing-like testa. 604. Section of the nucleus, showing the embryo in the midst of albumen.

1. SAXIFRAGEÆ. Herbs. Petals imbricate in æstivation. Capsule (when the carpels are united) either two-celled with the placentæ in the axis, or one-celled with parietal placentæ. — *Ex.* Saxifraga, Sullivantia (Fig. 599), Heuchera.

2. ESCALLONIEÆ. Shrubs. Capsule two-celled; the styles cohering or united into one. — *Ex.* Escallonia of South America, Itea.

3. HYDRANGEÆ. Shrubs. Petals valvate in æstivation. Capsule two (rarely five to ten) celled: the styles or stigmas distinct or united. Stamens sometimes numerous. — *Ex.* Hydrangea, Decumaria.

4. PHILADELPHEÆ. Shrubs. Petals convolute in æstivation. Capsule three or four-celled: styles more or less united. Stamens mostly numerous. *Ex.* Philadelphus, the Mock Orange. — Of little consequence, except as ornamental plants. The roots are generally astringent; powerfully so in Heuchera, especially in the common H. Americana (sometimes called Alum-Root).

Group 18. ***Ovary compound, two (rarely one, three, or five) celled, with a single ovule suspended from the summit of each cell. Calyx adherent, usually completely incorporated with the ovary. Stamens as many as the petals (twice as many in*** **Hamamelis,** ***and numerous in*** **Fothergilla** ***only, where the petals are wanting), and inserted with them upon the throat of the calyx or an epigynous disk. Seeds with a small embryo in the midst of hard albumen. — Petals mostly valvate in æstivation.***

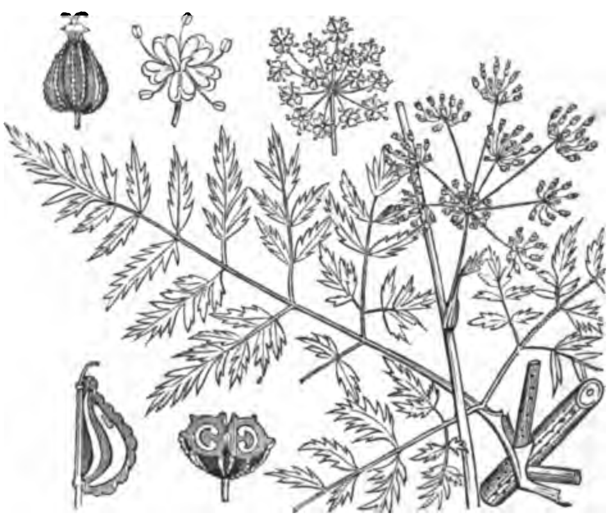
ORDER 66. HAMAMELACEÆ. Shrubs or small trees, with alternate simple leaves, without stipules. Flowers often polygamous. — Stamens twice as many as the petals, half of them sterile; or numerous, and the petals none. Summit of the ovary free from the calyx: styles two, distinct. Capsules cartilaginous or bony. Seeds bony.

Ex. Hamamelis (Witch-Hazel), Fothergilla. A small order of little known importance. Hamamelis is remark-

able for flowering late in autumn, and perfecting its fruit the following spring.

ORDER 67. UMBELLIFERÆ. Herbs, with hollow stems, and alternate, dissected leaves, with the petioles sheathing or dilated at the base. Flowers in simple or mostly compound umbels, which are occasionally contracted into a kind of head. — Calyx entirely coherent with the surface of the two-carpellary ovary; its limb reduced to a mere border, or to five small teeth. Petals five, inserted with the five stamens, on a disk which crowns the ovary;

608 607 606



610 609 605

their points inflexed. Styles two; their bases often united and thickened (forming a *stylopodium*). Fruit dry, separat-

FIG. 605. Conium maculatum (Poison Hemlock), a portion of the spotted stem, with a leaf; and an umbel with young fruit. 606. A flower umbellet. 607. A flower, enlarged. 608. The fruit. 609. Cross section of the same, showing the involute (*cœlospermous*) albumen of the two seeds. 610. Longitudinal section of one mericarp, exhibiting the minute embryo near the apex of the albumen.

ing from each other, and often from a slender axis (*carpophore*), into two indehiscent carpels (called *mericarps*): the faces by which these cohere receive the technical name of *commissure:* they are marked with a definite number of *ribs* (juga), which are sometimes produced into wings: the intervening spaces (*intervals*), as well as the commissure, sometimes contain canals or receptacles of volatile oil, called *vittæ:* these are the principal terms peculiarly employed in describing the plants of this difficult family.

Ex. The Carrot, Parsnip, Celery, Caraway, Anise, Coriander, Poison Hemlock, &c., are common representatives of this well known family. Nearly all Umbelliferous Plants are furnished with a volatile oil or balsam, chiefly accumulated in the roots and in the reservoirs of the fruit, upon which their aromatic and carminative properties depend: sometimes it is small in quantity, so as merely to flavor the saccharine roots which are used for food; as in the Carrot and Parsnip. But in many an alkaloid principle exists, pervading the foliage, stems, and roots, especially the latter,

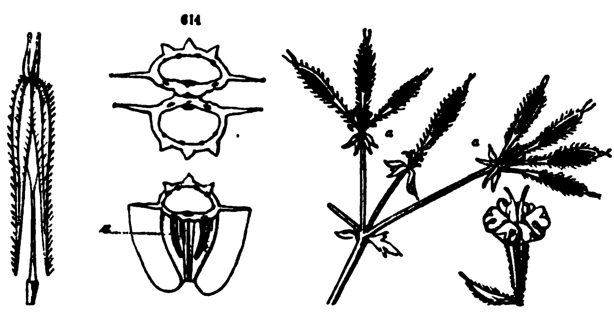


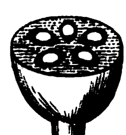
FIG. 611. Flower of Osmorrhiza longistylis. 612. Umbel of the same in fruit: *a*, the involucels. 613. The ripe mericarps separating from the axis or carpophore. 614. Cross section of the fruit of Angelica, where the lateral ribs are produced into wings: the black dots represent the vittæ, as they appear in a cross section. 615. One of the mericarps of the same, showing the inner face, or commissure, as well as the transverse section, with two of the vittæ, *a*.

which renders them acrid-narcotic poisons. And finally, many species of warm regions yield odorous gum-resins (such as Galbanum, Assafœtida, &c.), which have active stimulant properties. The stems of Celery (Apium graveolens), which are acrid and poisonous when the plant grows wild in marshes, &c., are rendered innocent by cultivation in dry ground, and by blanching. Among the virulent acrid-narcotic species, the most famous are the Hemlock (Conium maculatum, naturalized in this country); and Cicuta maculata (Cowbane, Water Hemlock) of this country; the root of which (like that of C. virosa in Europe) is a deadly poison. A drachm of the fresh root has killed a boy in less than two hours.

ORDER 68. ARALIACEÆ. A small family, scarcely differing from Umbelliferæ in botanical character, except that the ovary is composed of more than two carpels, which do not separate when ripe, but become drupes or berries; and the albumen is not hard like horn, but only fleshy.

Ex. Aralia (the Spikenard, the Wild Sarsaparilla, and the Angelica-tree), Panax (Ginseng), and Hedera (the Ivy). Their properties are aromatic, stimulant, somewhat tonic, and alterative.


616


617


618

FIG. 616. Flower of Aralia nudicaulis (Wild Sarsaparilla); a vertical section, displaying two of the cells of the ovary. 617. Cross section of the ovary. 618. Longitudinal section of a seed magnified, showing the small embryo at the upper end.

Order 69. CORNACEÆ. Chiefly trees or shrubs; with the leaves almost always opposite, destitute of stipules. Flowers in cymes, sometimes in heads surrounded by colored involucres. Calyx coherent with the two-celled ovary; the very small limb four-toothed. Stamens four, alternate with the petals. Styles united into one. Fruit a two-celled drupe.

621

619 620

Ex. Cornus, the Dogwood. Chiefly remarkable for their bitter and astringent bark, which in this country has been advantageously substituted for Cinchona. The peculiar principle they contain is named *Cornine*. Cornus Canadensis (Fig. 619) is a low and herbaceous species.

Order 70. LORANTHACEÆ. Half-shrubby evergreens, parasitic on trees (64), with articulated branches, opposite coriaceous leaves, with scarcely any apparent veins and no stipules. Flowers sometimes imperfect, occasionally without floral envelopes, often with no petals, and when these are present they are frequently united in a monopetalous corolla. Stamens as many as the petals, and opposite them! or, when these are wanting, as many as the lobes of the calyx, and inserted on them! Ovary one-celled: style single or none. Fruit a one-seeded berry.

FIG. 619. Cornus Canadensis, with its involucrate head of flowers. 620. A separate flower, enlarged. 621. Section of the two-celled drupe, so as to show both the exocarp and the two-celled endocarp.

Ex. Loranthus; Viscum, the Mistletoe, which is apetalous. — The berries of Mistletoe yield a glutinous substance, from which *birdlime* is made. The bark is astringent.

Division II. — Monopetalous Exogenous Plants.*

Floral envelopes consisting of both calyx and corolla: the petals more or less united (corolla gamopetalous, 299).
so as to form a tube...

Conspectus of the Groups and Orders.

Group 1. Ovary coherent with the calyx (inferior), two to several-celled, with one or many ovules in each cell. Seeds albuminous. Stamens inserted on the corolla.

71. Caprifoliaceæ. 72. Rubiaceæ.

Group 2. Ovary coherent with the calyx, one-celled and one-ovuled; rarely three-celled with two of the cells empty. Seeds with little or no albumen. Stamens inserted on the corolla.

*** Stamens distinct. Seed suspended.**

73. Valerianaceæ. 74. Dipsaceæ.

*** * Stamens syngenesious. Seed erect.**

75. Compositæ.

Group 3. Ovary coherent with the calyx, with two or more cells and numerous ovules. Seeds albuminous. Stamens inserted with the corolla (epigynous): anthers not opening by pores.

76. Lobeliaceæ. 77. Campanulaceæ.

Group 4. Ovary free from the calyx (superior), or sometimes coherent with it, with two or more cells and numerous ovules. Seeds albuminous. Stamens inserted with the corolla, or rarely coherent with its base, as many, or twice as many, as its lobes: anthers mostly opening by pores or chinks.

78. Ericaceæ.

---

* Cucurbitaceæ, placed in the polypetalous series, are commonly monopetalous: so are some exotic Crassulaceæ.

Group 5. Ovary free, or rarely coherent with the calyx, several-celled, with a single ovule (or at least a single seed) in each cell. Stamens definite: anthers not opening by pores. — Trees or shrubs.

79. Aquifoliaceæ. 80[2]. Styraceæ.
80. Ebenaceæ. 81. Sapotaceæ.

Group 6. Ovary free, or with the base merely coherent with the tube of the calyx, one-celled, with a free central placenta. Stamens inserted into the regular corolla opposite its lobes! which they equal in number.

82. Myrsinaceæ. 83. Primulaceæ.

Group 7. Ovary free, one-celled with a single ovule; or two-celled with several ovules attached to a thick central placenta. Stamens as many as the lobes of the regular corolla or the nearly distinct petals.

84. Plantaginaceæ. 85. Plumbaginaceæ.

Group 8. Ovary free, one or two (or spuriously four) celled, with numerous ovules. Corolla bilabiate or irregular; the stamens inserted upon its tube, and mostly fewer than its lobes.

* Ovary one-celled, with a free central placenta.

86. Lentibulaceæ.

* * Ovary one-celled, with parietal placentæ.

87. Orobanchaceæ.

* * * Ovary two-celled, with the placentæ in the axis.

88. Bignoniaceæ. 90. Acanthaceæ.
89. Pedaliaceæ. 91. Scrophulariaceæ.

Group 9. Ovary free, two to four-lobed, and separating or splitting into as many one-seeded nuts or achenia. Corolla regular or irregular; the stamens inserted on its tube, equal in number or fewer than its lobes.

92. Verbenaceæ. 93. Labiatæ.
94. Boraginaceæ.

Group 10. Ovary free, compound, or the carpels two or more and distinct: the ovules usually several or numerous. Corolla regular; the stamens inserted upon its tube, as many as the lobes and alternate with them.

* Ovary compound (of two or more united carpels).

95. Hydrophyllaceæ. 98. Diapensiaceæ.
96. Hydroleaceæ. 99. Convolvulaceæ.
97. Polemoniaceæ. 100. Solanaceæ.
101. Gentianaceæ.

* * Ovaries mostly two and distinct, at least in fruit.

102. APOCYNACEÆ. 103. ASCLEPIADACEÆ.

Group 11. Ovary free, two-celled, few-ovuled; the cells of the fruit one-seeded. Corolla regular (sometimes nearly polypetalous or wanting); the stamens (two) fewer than its lobes. — Shrubs or trees.

104. JASMINACEÆ. 105. OLEACEÆ.

Group 1. *Ovary coherent with the calyx (inferior), two to several-celled, with one or many ovules in each cell. Seeds albuminous. Stamens inserted on the corolla.*

ORDER 71. CAPRIFOLIACEÆ. Mostly shrubs, often twining, with opposite leaves, and no stipules. — Limb of the calyx five (rarely four) cleft or toothed. Corolla tubular or rotate, regular or irregular. Stamens as many as the petals of which the corolla is composed, and alternate

FIG. 622. Branch of Lonicera (Xylosteon) oblongifolia: the two ovaries united! 623. Lonicera (Caprifolium) parviflora. 624. A flower about the natural size. 625. Longitudinal section of the ovary. 626. Longitudinal section of a magnified seed, showing the albumen and minute embryo.

with them, or rarely one fewer. Fruit mostly a berry or drupe. Seeds pendulous.

Ex. The Honeysuckles (Lonicera, Fig. 622, 623, which are prized in cultivation), which have usually a peculiar bilabiate corolla (309), the Snowberry (Symphoricarpus), Diervilla, which has capsular fruit, &c., compose the tribe LONICEREÆ, characterized by their tubular flowers and filiform style: while the Elder (Sambucus) and Viburnum, which have a rotate or urn-shaped corolla, form the tribe SAMBUCEÆ. These plants chiefly belong to temperate regions. They are generally bitter, and rather active or nauseous in their properties: but the fruit of some few is edible.

ORDER 72. RUBIACEÆ. Shrubs or trees, or often herbs, with the entire leaves either in whorls, or opposite

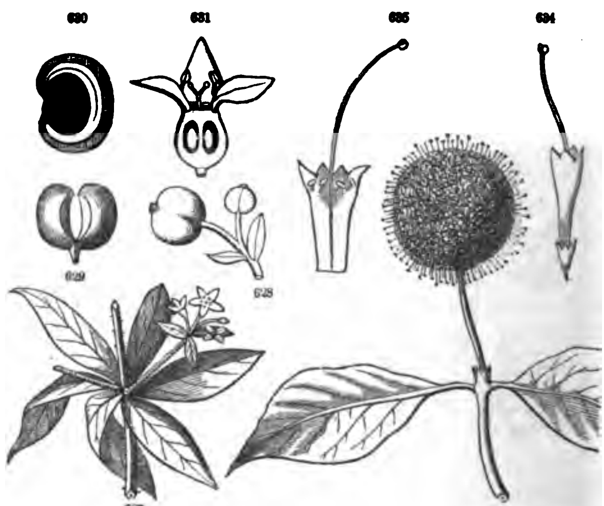


FIG. 627. Piece of Rubia tinctoria (the Madder) in flower. 628. The fruit. 629. The two constituent portions of the fruit separating. 630. Vertical section of one carpel, showing the curved embryo. 631. Section of a flower of Galium.

FIG. 632. Cephalanthus occidentalis, the Button-bush. 634. A flower, taken from the head. 635. The corolla laid open.

and furnished with stipules. — Calyx sometimes incompletely united with the ovary, the limb four or five-cleft or toothed, or occasionally obsolete. Stamens as many as the lobes of the regular corolla, and alternate with them. Fruit various. — This extensive family divides into two suborders, to which a third may be appended, which differs in the nearly free ovary, and is by most botanists deemed a distinct order.

1. Stellatæ. Herbs, with the leaves in whorls; but all except a single pair are generally supposed to take the place of stipules. — *Ex.* Galium, Rubia (the Madder, Fig. 627), &c., nearly all belonging to the colder parts of the world.

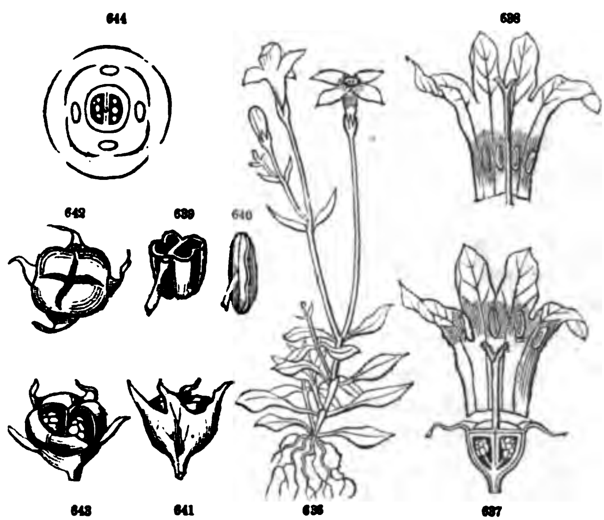


FIG. 636. Hedyotis (Houstonia) cærulea. 637, 638. The two sorts of flowers that different individuals bear, with the corolla laid open; one with the stamens at the base, the other at the summit of the tube: the lower figure shows also a section of the ovary. 639. Cross section of an anther, magnified. 640. Anther less enlarged, opening longitudinally. 641. Capsule with the calyx. 642, 643. Views of the capsule in dehiscence. 644. Diagram of a cross section of the unexpanded flower.

2. CINCHONEÆ. Shrubs, trees, or herbs; the leaves opposite and furnished with stipules, which are very various in form and appearance. — *Ex.* Cephalanthus (Button-bush, Fig. 632), Pinckneya, Hedyotis (Fig. 636), and an immense number of tropical genera. Their stipules distinguish them from Caprifoliaceæ.

3. LOGANIEÆ, or SPIGELIEÆ. Leaves opposite, with intermediate stipules. Ovary nearly or entirely free from the persistent calyx. — *Ex.* Mitreola, Spigelia, Cœlostylis, and other genera intermediate between Rubiaceæ and Apocynaceæ.

Very active, and generally febrifugal properties prevail in this large order. The roots of Madder yield a most important dye: and many Galiums have a similar red coloring matter. — The division Cinchoneæ furnishes two of the most valuable known remedial agents, namely, *Peruvian bark*, or *Cinchona*, and *Ipecacuanha*. The febrifugal properties of the former depend on the presence of two alkalis, *Cinchonia* and *Quinia*, both combined with *Kinic acid*. The *Quinquina barks*, which are derived from some species of Exostemma and other West Indian, Mexican, and Brazilian genera, contain neither cinchonia nor quinia. The bark of Pinckneya pubens, of the Southern United States, has been substituted for Cinchona. — The true *Ipecacuanha* is furnished by the roots of Cephaælis Ipecacuanha of Brazil and the mountains of New Granada. Its emetic principle (called *Emetina*) also exists in Psychotria emetica of New Granada, which furnishes the *striated*, *black*, or *Peruvian Ipecacuanha*. *Coffee* is the horny seed (albumen) of Coffæa Arabica. — The roots and leaves of Spigelia Marilandica (Carolina Pink-root), are commonly used as a vermifuge.

Group 2. *Ovary coherent with the calyx (the limb of which assumes the form of a crown or pappus, or else is obsolete), one-*

celled, or sometimes with two empty cells, one-ovuled. Seeds with little or no albumen. Stamens inserted on the corolla. Fruit a kind of achenium. — Flowers commonly crowded into heads.

ORDER 73. VALERIANACEÆ. Herbs with opposite leaves, and no stipules. Flowers often in cymes or panicles. Limb of the calyx two to four-toothed, obsolete, or else forming a kind of pappus. Corolla tubular or funnel-form, sometimes with a spur at the base, four or five-lobed. Stamens distinct, usually fewer than the lobes of the corolla. Ovary with one perfect cell and two abortive ones. Seed suspended.

Ex. Valeriana, the Valerian; Fedia, the Lamb-lettuce (Fig. 645): the latter is eaten as a salad. The roots, &c.,

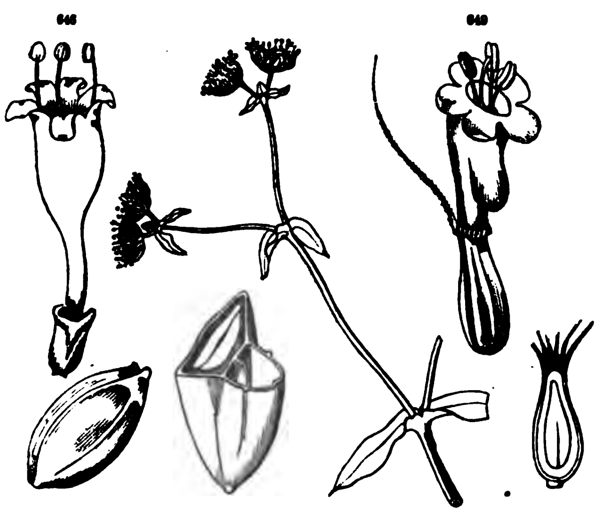


FIG. 645. Branch of Fedia Fagopyrum. 646. A magnified flower. 647. A fruit. 648. An enlarged cross section of the same, and the cotyledons of the seed in the single fertile cell: the two empty cells are confluent into one.

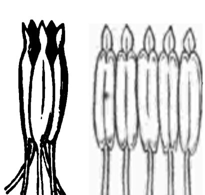
FIG. 649. Flower of a Valerian, with one of the pappus-like bristles of the calyx unrolled. 650. Section through the ovary and embryo; the bristles of the calyx broken away.

of the perennial species exhale a heavy and peculiar odor, have a somewhat bitter, acrid taste, and are antispasmodic and vermifugal. The *Valerian* of the shops is chiefly derived from Valeriana officinalis of the South of Europe. It produces a peculiar intoxication in cats. The roots of V. edulis are used for food by the aborigines of Oregon. The *Spikenard* of the ancients, esteemed as a stimulant medicine as well as a perfume, is the root of Nardostachys Jatamansi of the mountains of the North of India.

ORDER 74. DIPSACEÆ. Herbs, with opposite or whorled sessile leaves, destitute of stipules. Flowers in dense heads, which are surrounded by an involucre. — Limb of the calyx cup-shaped and entire or toothed, or forming a bristly or plumose pappus. Corolla tubular; the limb four or five-lobed, somewhat irregular. Stamens four, distinct, or rarely united in pairs, often unequal. Ovary one-celled. Seed suspended.

Ex. Dipsacus, the Teasel, and Scabiosa, or Scabious. All natives of the Old World. Some are cultivated for ornament. *Teasels* are the dried heads of Dipsacus Fullonum, covered with stiff and spiny bracts, with recurved points.

ORDER 75. COMPOSITÆ. Herbs or shrubs; with the flowers in heads (compound flowers of the older botanists), crowded on a receptacle, and surrounded by a set of bracts (*scales*) forming an involucre; the separate flowers often furnished with bractlets (*chaff*, *paleæ*). — Limb of the calyx obsolete, or a *pappus* (305), consisting of hairs, bristles, scales, &c. Corolla regular or irregular. Stamens five, as many as the lobes or teeth of



a 650 *b*

FIG. 650, *a*. Syngenesious stamens of a Composita. *b*. The anthers laid open.

the regular corolla: anthers united into a tube (*syngenesious*, Fig. 650). Style two-cleft. Fruit an achenium with a single erect seed, either naked or crowned with a pappus. — This vast but very natural family is divided into three sets or suborders, namely: —

1. TUBULIFLORÆ. Corolla tubular and regularly four or five-lobed, either in all the flowers (when the head is *discoid*), or in the central ones (those of the *disk*) only, the marginal or *ray-flowers* presenting a *ligulate* or strap-shaped corolla. — *Ex.* Liatris (Fig. 651), Eupatorium, &c.; where the heads are *homogamous*, that is, the flowers all tubular, similar, and perfect: Helianthus (Sunflower), Helenium (Fig. 654), Aster, &c.; where the heads are *heterogamous;* the *disk*-flowers being tubular and perfect, while those of the *ray* are *ligulate*, and either pistillate only, or *neutral* (306, note), that is, destitute of both stamens and pistils.

2. LABIATIFLORÆ. Corolla of the disk-flowers bilabiate. — *Ex.* Chaptalia (the only one of the United States), Mutisia, Chætanthera, &c., of South America.

3. LIGULIFLORÆ. Corolla of all the flowers (both disk and ray) ligulate; all perfect. — *Ex.* The Dandelion, Lettuce, Cichory, &c.

This vast family comprises about a tenth part of all Flowering Plants. A bitter and astringent principle pervades the whole order; which in some is tonic (as in the Camomile, Anthemis nobilis; the Boneset, or Thoroughwort, Eupatorium perfoliatum, &c.); in others combined with mucilage, so that they are demulcent as well as tonic (as in Elecampane, and Colts-foot); in many, aromatic and extremely bitter (such as Wormwood and all the species of Artemisia); sometimes accompanied by acrid qualities, as in the Tansy (Tanacetum vulgare), and the Mayweed (Maruta Cotula), the bruised fresh herbage of which promptly blisters the skin. The species of Liatris, which abound

in terebinthine juice, are among the reputed remedies for the bites of serpents. The juice of Silphium appears to

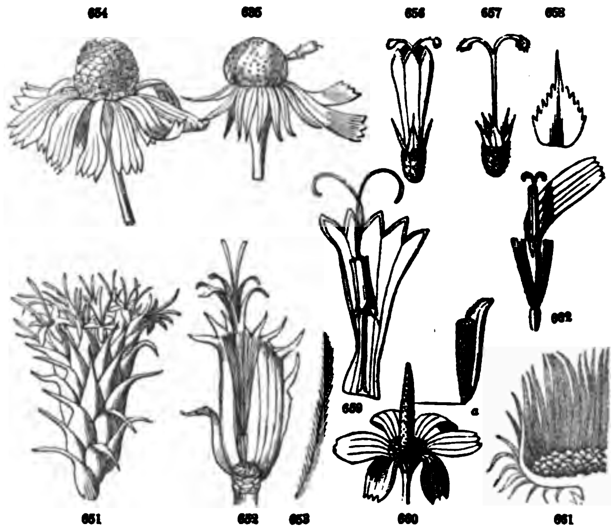


FIG. 651. Head of Liatris squarrosa (discoid; the flowers all tubular and perfect). 652. The same, with the scales of one side of the imbricated involucre removed; and also all the flowers but one, showing the naked flat receptacle. 653. Portion of one of the plumose bristles of the capillary pappus. 654. Head of Helenium autumnale (heterogamous); the rays neutral, consisting merely of a ligulate corolla. 655. The same, with the flowers all removed from the roundish receptacle, except a single disk-flower and one or two rays: the reflexed scales of the involucre in a single series. 656. Magnified disk-flower of the same; the corolla exhibiting the peculiar venation of the family; namely, the veins corresponding to the sinuses, and sending a branch along the margins of the lobes. 657. The same with the corolla removed; the achenium crowned with the limb of the calyx in the form of a chaffy pappus, of about five scales. 658. A chaff of the pappus more magnified. 659. A tubular corolla of this family laid open, showing the venation; and also the five syngenesious anthers united in a tube, through which the two-cleft style passes. 660. Head of Dracopis amplexicaulis, with the flowers removed from the elongated spike-like receptacle, except a few at the base: *a*. Achenium of one of the disk-flowers, magnified, partly inclosed by its bractlet (chaff or palea); the pappus obsolete. 661. Part of the involucre and alveolate (honeycomb-like) receptacle of Onopordon or Cotton-Thistle. 662. A perfect and ligulate flower of the Dandelion, with its hair-like or capillary pappus.

be a nearly pure resin. The leaves of Solidago odora, which owe their delightful anisate fragrance to a peculiar volatile oil, are infused as a substitute for tea. From the seeds of Sunflower, and several other plants of the order, a bland oil is expressed. The tubers of Helianthus tuberosus are eaten under the name of *Jerusalem artichokes*. True *artichokes* are the fleshy receptacle of Cynara Scolymus. The flowers of Carthamus tinctorius, often called Saffron, yield a yellow dye. — The Ligulifloræ, or Cichoraceæ, all have a milky juice, which is narcotic, and has been employed as a substitute for *opium*. The bland young leaves of the Garden Lettuce are a common salad. The roasted roots of the Wild Succory (Cichorium Intybus) are extensively used in France as a substitute for coffee: and the roots of some species of Tragopogon (Salsify, Oyster-plant) and Scorzonera are well known esculents.

Group 3. *Ovary coherent with the calyx, two to seven-celled (rarely one-celled), with numerous ovules. Seeds albuminous. Stamens inserted with the corolla upon an epigynous disk: anthers not opening by pores.*

ORDER 76. LOBELIACEÆ. Herbs or somewhat shrubby plants; often yielding a milky juice, with alternate leaves and usually showy flowers. — Limb of the corolla five-cleft. Corolla irregularly five-lobed, usually appearing bilabiate, cleft on one side nearly or quite to the base. Stamens coherent into a tube. Stigma fringed. Fruit capsular, two or three (rarely one) celled, many-seeded.

Ex. Lobelia (Fig. 654, bis), Clintonia; the latter (Californian annuals not uncommon in cultivation) remarkable for their one-celled pods, with two parietal placentæ. All narcotico-acrid poisons. The well known Lobelia inflata (Indian Tobacco) is one of the most powerful articles of the materia medica, and the most dangerous in the hands of the reckless

quacks that use it. Less than a tea-spoonful of the seeds or powdered leaves will destroy life in a few hours.

ORDER 77. CAMPANULACEÆ. Herbs, with a milky (slightly acrid) juice, alternate leaves, and usually showy flowers. — Limb of the calyx commonly five-cleft, persistent. Corolla regular, campanulate, usually five-lobed, withering. Stamens five, distinct. Style furnished with collecting hairs. Capsule two to several-celled, many-seeded.

Ex. Campanula (Fig. 653, bis). Of little known importance, except for ornament.

FIG. 653, bis. Campanula rotundifolia, much reduced in size. 654'. Lobelia inflata, reduced in size. 655'. A flower enlarged. 656'. The united filaments and anthers inclosing the style; the corolla and limb of the calyx cut away. 657'. The stigma surrounded by a fringe. 658'. Transverse section of a capsule. 659'. Section of a magnified seed, showing the embryo.

Group 4. *Ovary free (superior), or sometimes coherent with the calyx, with two or more cells, and (usually) numerous ovules. Seeds albuminous. Stamens inserted with the corolla (either hypogynous or epigynous), or rarely adherent to its base; the anthers as many or twice as many as its lobes, commonly opening by a pore or chink. — Petals sometimes distinct.*

ORDER 78. ERICACEÆ. Shrubs or sometimes herbs. Flowers regular or nearly so. Stamens mostly distinct: anthers two-celled, often appendaged. Styles and stigmas united into one. Seeds usually indefinite. — Some botanists give the rank of orders to the following suborders.

1. VACCINIEÆ. Ovary adherent to the tube of the calyx, becoming a berry or a drupe-like fruit. — Shrubs, with scattered leaves, often evergreen. — *Ex.* Vaccinium (Whortleberry), Oxycoccus (the Cranberry).

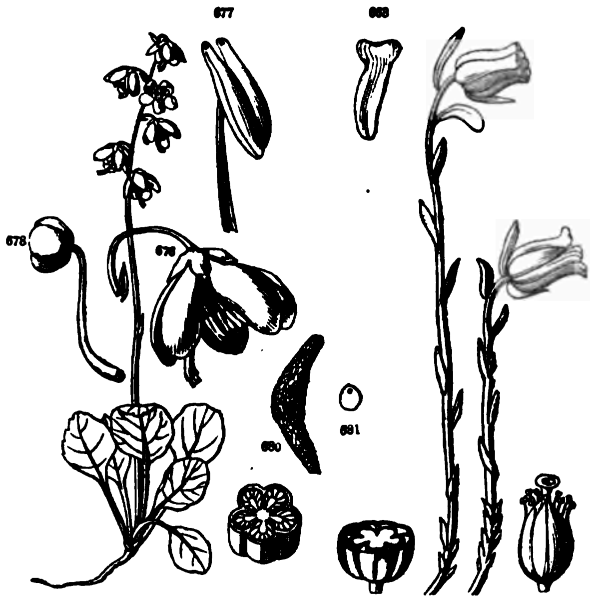
2. ERICINEÆ. Ovary free from the calyx. Fruit capsular, sometimes baccate or drupaceous. Testa conformed to the nucleus of the seed. — Mostly shrubs. Leaves various, acerose or flat, often evergreen. Petals rarely almost or entirely distinct. — *Ex.* Erica (Heath), Kalmia, Rhododendron (Fig. 660), Gaultheria (Fig. 664), Andromeda, &c.

FIG. 660, bis. Branch of Rhododendron Lapponicum. 661'. Enlarged flower, with its pedicel and bracts. 662'. Flower with the corolla removed, more enlarged. 663. Capsule of R. maximum, opening by septicidal dehiscence; the valves breaking away from the persistent axis, or columella.

3. PYROLEÆ. Ovary free from the calyx. Petals distinct or nearly so. Fruit a capsule. Seeds with a loose cellular testa, not conformed to the nucleus. — Mostly herbs. Leaves flat. — *Ex.* Pyrola (Fig. 675), Chimaphila, Galax.

FIG. 664. Gaultheria procumbens (Wintergreen, &c.). 665. The enlarging calyx in the immature fruit. 666. Vertical section of the pulpy or berry-like calyx and the included capsule (the seeds removed from the placenta in one cell). 667. Horizontal section of the same, showing the five-celled capsule, with a placenta proceeding from the inner angle of each cell. 668. Section of a seed, magnified. 669. Flower of a Vaccinium (Whortleberry). 670. Vertical section of the ovary and adherent calyx. 671. Anther of Vaccinium Vitis-Idæa; each cell prolonged into a tube, and opening by a terminal pore. 672. Anther of Vaccinium Myrtillus; the connectivum furnished with two appendages. 673. Stamen of an Andromeda (Cassiope), showing the appendages of the connectivum. 674. Stamen of Arctostaphylos Uva Ursi, showing the separate anther-cells, opening by a terminal pore, the appendages of the connectivum, and the filament, which is swollen at the base.

4. MONOTROPEÆ. Ovary free from the calyx. Petals distinct or united. Anthers opening longitudinally, or by transverse chinks. Fruit a capsule. Seeds with a loose or winged testa.—Parasitic herbs, destitute of green color, and with scales instead of leaves.—*Ex.* Monotropa (Fig. 682).



In this widely diffused order the bark and foliage is generally astringent, often stimulant or aromatic from a volatile oil or a resinous matter, and not seldom narcotic. Thus, the

FIG. 675. Pyrola chlorantha, reduced in size. 676. Enlarged flower. 677. Magnified stamen. 678. Pistil. 679. Cross section of the capsule. 680. A highly magnified seed. 681. The nucleus removed from the loose cellular testa, and divided, showing the very minute embryo.

FIG. 682. Monotropa uniflora. 683. A petal. 684. Capsule, with the stamens. 685. Transverse section of the same: the thick and lobed placenta covered with very minute seeds.

leaves of Rhododendron (Big Laurel, Rose-Bay, &c.), of Kalmia (called Laurel and Calico-bush in the Northern, and Ivy in the Southern States), and all the related plants, are deleterious (being stimulant narcotics), or suspicious. The honey made from their flowers is sometimes poisonous. The Uva-Ursi and the Chimaphila (Pipsissewa) are the chief medicinal plants of the order. The berries are generally edible (Whortleberries, Wintergreen, &c.). Many are very ornamental plants.

Group 5. *Ovary free, or rarely coherent with the calyx, several-celled, with a single ovule in each cell. Seeds with or without albumen. Stamens inserted on the tube of the regular (sometimes almost polypetalous) corolla, as many, or two to four times as many, as its lobes: anthers not opening by pores or chinks.—Trees or shrubs.*

ORDER 79. AQUIFOLIACEÆ. Trees or shrubs, commonly with coriaceous leaves, and small axillary flowers.—Calyx of four to six sepals. Corolla four to six-parted or cleft: the stamens as many as its segments and alternate with them. Ovary two to six-celled; the cells with a single suspended ovule. Fruit drupaceous, with two to six stones or nucules.

Ex. Ilex (the Holly), Prinos, &c. The bark and leaves contain a tonic, bitter, extractive matter. The leaves of a species of Ilex are used for tea in Paraguay: and the famous *black drink* of the Creek Indians is prepared from the leaves of Ilex vomitoria (Cassena); which are still used as a substitute for tea in some parts of the Southern States.

ORDER 80. EBENACEÆ. Trees or shrubs, destitute of milky juice, with alternate, mostly entire, leaves; often

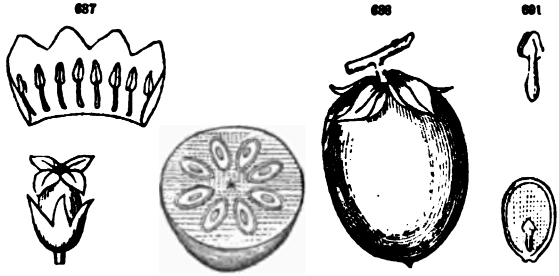
---

ORDER EPACRIDACEÆ, which takes the place of Heaths in Australia, essentially differs from Ericaceæ only in the one-celled anthers. Many are cultivated for ornament.

with polygamous flowers. — Calyx three to six-cleft, free from the ovary. Corolla three to six-cleft, often pubescent. Stamens twice to four times as many as the lobes of the corolla. Ovary three to several-celled; the style with as many divisions. Fruit a kind of berry, with bony seeds.

Ex. Diospyros; the Persimmon (Fig. 686 – 690). The fruit, which is extremely austere and astringent when green, is sweet and eatable when fully ripe. The bark is powerfully astringent. *Ebony* is the wood of D. Ebenus and other African and Asiatic species.

687 688 691



686 689 690

ORDER 80[a]. STYRACACEÆ. Shrubs or trees with perfect flowers. — Calyx-tube either coherent with the base of the ovary, or with its whole surface. Styles and stigmas perfectly united into one. Stamens more or less united.

Ex. Styrax, Halesia, Hopea, or Symplocos. Some yield a fragrant, balsamic resinous substance; such as Storax and Benzoin, containing *Benzoic acid.* The sweet leaves of our Hopea tinctoria afford a yellow dye.

ORDER 81. SAPOTACEÆ. Trees or shrubs, usually with a milky juice; the leaves alternate, entire, coriaceous, the upper surface commonly shining. Flowers perfect,

FIG. 686. Perfect flower of Diospyros Virginiana, the Persimmon. 687. The corolla, laid open, and stamens. 688. The fruit. 689. Section through the fruit and bony seeds. 690. Vertical section of a seed. 691. The detached embryo.

axillary, usually in clusters. — Calyx four to eight-parted. Corolla four to eight (or many) cleft. Stamens distinct, commonly twice as many as the lobes of the corolla, half of them fertile and opposite the lobes, the others mere sterile filaments and alternate with the lobes of the corolla; the latter rarely wanting; the fertile stamens sometimes more numerous: anthers extrorse. Ovary four to eight-celled, with a single ascending ovule in each cell. Styles united into one. Fruit a berry. Seeds with a bony testa.

Ex. Achras, Chrysophyllum, Bumelia of the Southern United States. The fruit of many species is sweet and eatable; such as the Sapodilla Plum, the Marmalade, the Star-Apple, and other West Indian species. The large seeds, particularly of some kinds of Bassia, yield a bland fixed oil, which is sometimes thick and like butter, as in the Chee of India (B. butyracea), and the African Butter-tree, or Shea, described by Mungo Park.

Group 6. *Ovary free (superior), or its base rarely coherent with the tube of the calyx, one-celled with a free central placenta! Ovules commonly indefinite. Seeds albuminous. Stamens inserted upon the tube of the regular corolla opposite its lobes, which they equal in number.*

Order 82. MYRSINACEÆ. Trees or shrubs, mostly with alternate coriaceous leaves, which are often dotted with glands, and a drupe or berry, frequently perfecting only one or few seeds. — Nearly all tropical (Ardisia, Myrsine).

Order 83. PRIMULACEÆ. Herbs, with opposite, whorled, or alternate leaves, often with naked scapes and the leaves crowded at the base. — Calyx four or five-cleft or toothed, usually persistent. Corolla rotate, hypocrateriform, or campanulate. Style and stigma single. Fruit capsular: the fleshy central placenta attached to the base of the cell. Seeds usually numerous and amphitropous.

Ex. Primula (Primrose), Cyclamen. Anagallis (Fig. 699). In Samolus, the calyx coheres with the base of the

ovary, and there is a row of sterile filaments occupying the normal position of the first set of stamens, namely, alternate with the lobes of the corolla. Of little consequence, except for their beauty.

FIG. 692. Primula pusilla. 693. The corolla removed; its tube laid open. 694. The calyx divided vertically, showing the pistil. 695. Vertical section of the ovary and of the free central placenta, covered with ovules, which nearly fills the cell. 696. Capsule of Primula veris, dehiscent at the summit by numerous teeth. 697. A magnified seed. 698. Section of the same, exhibiting the transverse embryo.

FIG. 699. Branch of Anagallis arvensis (Pimpernel), with a capsule showing the line of circumscissile dehiscence. 700. The capsule (pyxis, 412, 428), with the lid falling away.

Group 7. *Ovary free (superior), one-celled, with a single ovule suspended by a funiculus which arises from the base of the cell; or two-celled with one to several ovules attached to a thick central placentæ. Seeds albuminous. Stamens as many as the lobes of the regular corolla or the nearly distinct petals, either alternate with or opposite them. — Herbs, or rarely suffrutescent plants.*

ORDER 84. PLANTAGINACEÆ. Chiefly low herbs, with small spiked flowers on scapes, and ribbed radical leaves. — Calyx four-cleft, persistent. Corolla tubular or urn-shaped, membranaceous and persistent; the limb four-cleft. Stamens four, inserted on the tube of the corolla alternate with its segments; the persistent filaments long and flaccid. Ovary two-celled: style single. Capsule

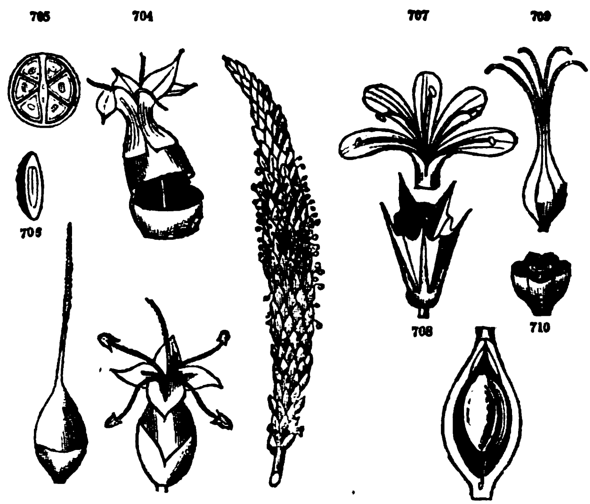


FIG. 701. Spike of the common Plantain. 702. A flower enlarged. 703. Pistil. 704. Capsule (pyxis, 428) with the marcescent corolla. 705. Cross section of the capsule and seeds. 706. Vertical section of a seed.

FIG. 707. Corolla, and 708, calyx of Thrift (Armeria vulgaris). 709. Pistil with distinct styles. 710. Cross section of the pod and seed. 711. Vertical section of the ovary magnified, to show the ovule (377).

(pyxis) membranaceous, opening by circumscissile dehiscence; the cells one to several-seeded.

Ex. Plantago, the Plantain, or Ribgrass (Fig. 701), is the principal genus of the order.

ORDER 85. PLUMBAGINACEÆ. Perennial herbs, or somewhat shrubby plants; with the flowers often on simple or branching scapes; and the leaves crowded at the base, entire, mostly sheathing or clasping. — Calyx tubular, plaited, five-toothed, persistent. Corolla hypocrateriform, with a five-parted limb, the five stamens inserted on the receptacle opposite its lobes (Plumbago); or else of five almost distinct unguiculate (scarious or coriaceous) petals, with the stamens inserted on their claws (Statice, &c.)! In the former case the five styles are united nearly to the top; but in the latter they are separate! Ovary one-celled, with a single ovule pendulous from a strap-shaped funiculus which rises from the base of the cell. Fruit an utricle, or opening by five valves.

Ex. Statice (Marsh Rosemary, Sea Lavender), and Armeria (Thrift, Fig. 707); sea-side or saline plants. The Statices have astringent roots; none more so than those of our own Marsh Rosemary (S. Caroliniana), one of the best and most intense astringents of the materia medica.

Group 8. *Ovary free (superior), one or two (or spuriously four) celled, with numerous ovules. Corolla bilabiate, or more or less irregular; the stamens inserted upon its tube, and mostly fewer than its lobes.*

ORDER 86. LENTIBULACEÆ. Herbs, growing in water, or wet places, with the flowers on scapes; the leaves either submersed and dissected into filiform segments resembling rootlets, and commonly furnished with air-bladders to render them buoyant; or, when produced in the air, entire and somewhat fleshy, clustered at the base of the

scape. Flowers showy, very irregular. — Calyx of two sepals, or unequally five-parted. Corolla bilabiate, personate; the very short tube spurred. Stamens two, inserted on the upper lip of the corolla: anthers one-celled. Ovary one-celled, with a free central placenta! bearing numerous ovules. Fruit a capsule. Seeds destitute of albumen.

Ex. Utricularia (Bladder-wort), Pinguicula. Unimportant plants.

ORDER 87. OROBANCHACEÆ. Herbs, destitute of green foliage, and with scales in place of leaves, parasitic

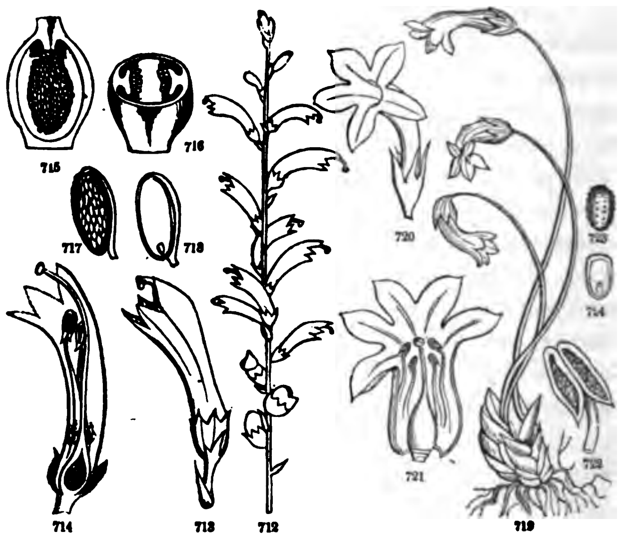


FIG. 712. Branch of Epiphegus Virginiana (Beech-drops), nearly of the natural size: the lower flowers, with short imperfect corollas, alone producing ripe seeds. 713. A flower enlarged. 714. Longitudinal section of the same. 715. Longitudinal section of the ovary more magnified, showing one of the parietal placentæ covered with minute ovules. 716. Cross section of the same, showing the two parietal placentæ. 717. A highly magnified seed. 718. Section of the same, exhibiting the minute embryo next the hilum.

FIG. 719. Orobanche uniflora, reduced in size. 720. A flower about the size of nature. 721. The same laid open, showing the didynamous stamens and the pistil. 722. A magnified anther. 723. A magnified seed. 724. Section of the same.

on the roots of other plants: the flowers solitary or spicate. —Calyx persistent, four or five-toothed or bilabiate. Corolla withering or persistent, with a bilabiate or more or less irregular limb. Stamens four, didynamous. Ovary one-celled, with two parietal placentæ! which are often two-lobed, or divided. Capsule inclosed in the persistent corolla. Seeds very numerous, minute. Embryo minute at the extremity of the albumen.

Ex. Orobanche, Epiphegus (Beech-drops), &c. Astringent, bitter, and escharotic. The pulverized root of Epiphegus (thence called Cancer-root) is applied to open Cancers.

ORDER 88. BIGNONIACEÆ. Mostly trees, or climbing or twining shrubby plants, with large and showy flowers, and opposite, simple, or mostly pinnately-compound, leaves. —Calyx five-parted, two-parted, or bilabiate, often spathaceous. Corolla with an ample throat, and a more or less irregular five-lobed or bilabiate limb. Stamens five, of which one, and often three, are reduced to sterile filaments or rudiments: when four are fertile they are didynamous. Ovary two-celled, with the placentæ in the axis; the base surrounded by a fleshy ring or disk. Capsule woody or coriaceous, pod-shaped, two-valved, many-seeded. Seeds commonly winged, destitute of albumen. Cotyledons foliaceous.

Ex. Bignonia (Trumpet Creeper), Catalpa; and other tropical genera. Of little known importance, except as ornamental plants.

ORDER GESNERIACEÆ, consisting of tropical herbs, with green foliage and showy flowers, the calyx often partly adherent to the ovary, agrees with Orobanchaceæ in the parietal placentation; by which both are distinguished from all other orders of this group.

ORDER 89. PEDALIACEÆ. Usually viscid herbs, differing from Bignoniaceæ by their few and wingless seeds; the fruit indurated or drupaceous, often two to four-horned, sometimes perforated in the centre from the dissepiments not reaching the axis before they diverge and become placentiferous, and spuriously four to eight-celled by the various cohesion of parts of the placentæ with the walls of the pericarp.

Ex. Martynia (Unicorn-plant), and some other tropical plants.

ORDER 90. ACANTHACEÆ. Herbs or shrubby plants, with bracteate, often showy, flowers, and opposite, simple leaves, without stipules. — Calyx of five sepals united at the base, or combined into a tube, persistent. Corolla bilabiate, or sometimes nearly equally five-lobed: æstivation twisted. Stamens four and didynamous, or only two, the anterior pair being abortive or obsolete. Ovary two-celled, with the placentæ in the axis, often few-ovuled. Seeds (sometimes only one or two in each cell) usually supported by hooked processes of the placenta, destitute of albumen.

Ex. Acanthus, Dicliptera, Thunbergia: the greater part tropical. Many are ornamental.

ORDER 91. SCROPHULARIACEÆ. Herbs, or sometimes shrubby plants; with opposite, verticillate, or alternate leaves. — Calyx of four or five more or less united sepals, persistent. Corolla bilabiate, personate, or more or less irregular; the lobes imbricated in æstivation. Stamens four and didynamous, the fifth stamen sometimes appearing in the form of a sterile filament, or very rarely antheriferous; or often only two, one pair being either suppressed or reduced to sterile filaments. Ovary two-celled, with the placentæ united in the axis. Capsule two-valved. Seeds indefinite, albuminous.

Ex. Scrophularia, Verbascum (Mullein, which is remarkable for the nearly regular corolla, with five perfect stamens), Linaria and Antirrhinum (Snapdragon), &c. — The plants of this large and important order are generally to be suspected of deleterious (bitter, acrid, or drastic) properties. The most important medicinal plant is the Fox-glove (Digitalis purpurea), so remarkable for its power of lowering the pulse. Numerous species are cultivated for ornament.

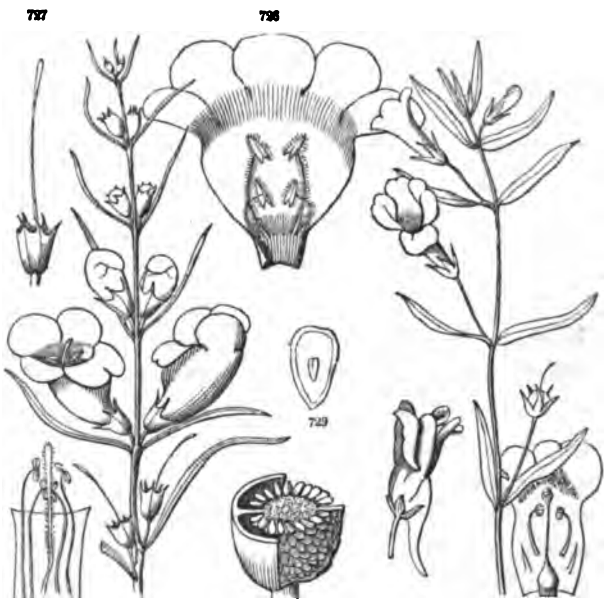


FIG. 725. Branch of Gerardia purpurea. 726. Corolla of the natural size, laid open. 727. Calyx and style of the same. 728. Magnified transverse section of the capsule, with one of the valves removed. 729. Magnified section of a seed.

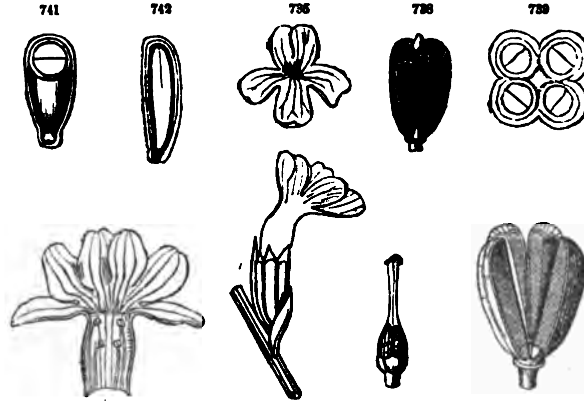
FIG. 731. Gratiola aurea, natural size. 732. Corolla laid open, showing the two perfect stamens and two rudimentary filaments (306) as well as the pistil. 730. The perfect stamens and sterile filament of Chelone. 733. Flower of a Linaria (Toad-flax, or Snapdragon), with a personate corolla (336).

Group 9. *Ovary free (superior), either two to four-lobed and in fruit forming as many one-seeded achenia or little nuts; or else entire and drupaceous, including as many one-seeded nucules, sometimes dry and separable: but the cells never more than two-ovuled. Corolla regular or irregular; the stamens inserted upon its tube, equalling its lobes, or fewer in number.*

ORDER 92. VERBENACEÆ. Herbs, shrubs, or even trees in the tropics, mostly with opposite leaves. — Calyx tubular, four or five-toothed, persistent. Corolla bilabiate, or the four or five-lobed limb more or less irregular. Stamens mostly four and didynamous, occasionally only two. Ovary entire, two to four-celled. Fruit drupaceous, baccate, or dry, and splitting into two to four indehiscent one-seeded portions. Seeds with little or no albumen.

Ex. Verbena (Vervain, Fig. 734 – 741) is the principal representative in cooler regions. There are many others in the tropics, mostly trees; one of which is the gigantic Indian

741 742 735 738 739



736 734 737 740

FIG. 734 and 735. Flower of a Verbena enlarged. 736. The corolla laid open. 737. Pistil. 738. The fruit. 739. Cross section of the young fruit and the contained seeds. 740. Fruit separating into its four nucules. 741. Cross section of one nucule or pericarp, and a vertical section of the lower part, showing the surface of the contained seed. 742. Vertical section through the nucule, seed, and embryo.

Teak (Tectona grandis), remarkable for its very heavy and durable wood, which abounds in silex. The leaves of the Aloysia citriodora of the gardens yield an agreeable perfume. Others are bitter and aromatic.

ORDER 93. LABIATÆ. Herbs, or somewhat shrubby plants, with quadrangular stems, and opposite or sometimes whorled leaves, replete with receptacles of volatile oil. Flowers in axillary or terminal cymules (280), rarely solitary. — Calyx tubular, persistent, five-toothed or cleft, or bilabiate. Corolla bilabiate. Stamens four, didynamous, or only two, one of the pairs being abortive or wanting. Ovary deeply four-lobed; the style proceeding from the base of the lobes. Fruit consisting of four (or fewer) little nuts or achenia, included in the persistent calyx. Seeds with little or no albumen.

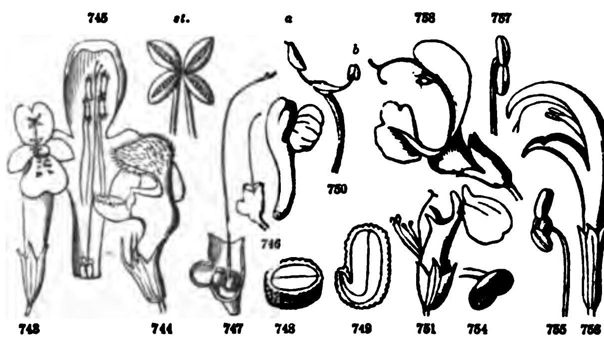


FIG. 743. Flower of Glechoma hederacea, or Ground Ivy: *st*. Approximate anthers of one pair of stamens magnified. 744. Flower of a Lamium. 745. Corolla of L. amplexicaule (Dead Nettle) laid open, showing the didynamous stamens, &c. 746. Calyx and corolla of Scutellaria galericulata (Skull-cap). 747. Section of the enlarged calyx of the same, bringing to view the deeply four-lobed ovary, raised on a short gynobase. 748. Cross section of a magnified achenium. 749. Vertical section of the same, showing the embryo. 751. Flower of Teucrium Canadense (309). 754. Magnified anther of the same. 755. Stamen of the Thyme (348). 756. Flower of Monarda. 757. Magnified anther of the same. 758. Flower of a Salvia; the calyx as well as the corolla bilabiate. 750. Magnified stamen of the same (348), with widely separated anther-cells, one of which (*a*) is polliniferous, the other (*b*) imperfect.

Ex. The Sage, Rosemary, Lavender, Thyme, Mint, &c., are familiar representatives of this universally recognized order. Their well known cordial, aromatic, and stomachic qualities depend upon a volatile oil, contained in glandular receptacles which abound in the leaves and other herbaceous parts, with which a bitter principle is variously mixed. None are deleterious.

ORDER 94. BORAGINACEÆ. Herbs, or sometimes shrubby plants; with round stems, and alternate, rough leaves; the flowers often in one-sided clusters (275), which are spiral before expansion. — Calyx of five leafy and persistent sepals, more or less united at the base, regular. Corolla regular; the limb five-lobed, often with a row of scales in the throat. Stamens as many as the lobes of the

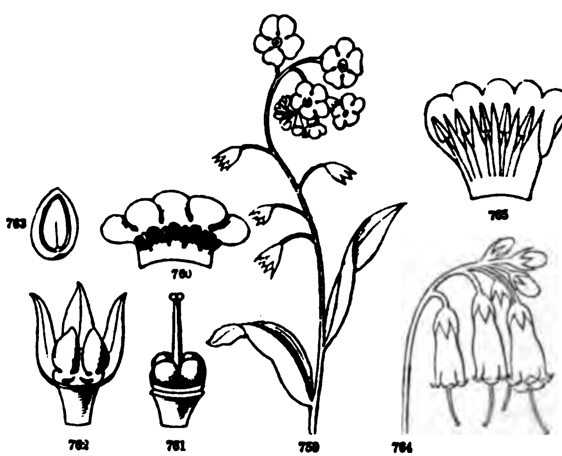


FIG. 759. Myosotis, or Forget-me-not. 760. The rotate corolla laid open; showing the scales of the throat, and the short stamens. 761. The pistil, with its four-lobed ovary. 762. The calyx in fruit; two of the little nuts having fallen away from the receptacle. 763. Section of a nut, or rather achenium, showing the embryo. 764. Raceme of Symphytum officinale (Comfrey). 765. A corolla laid open; exhibiting the lanceolate and pointed scales of the throat, alternate with the stamens.

corolla and alternate with them. Ovary deeply four-lobed, the style proceeding from the base of the lobes, which in fruit become little nuts or hard achenia. Seeds with little or no albumen.

Ex. Borago (Borage), Lithospermum, Myosotis (Fig. 759), Cynoglossum (Hound's-tongue), Heliotropium, &c. — In Echium, the limb of the corolla is somewhat irregular, and the stamens unequal. Innocent mucilaginous plants with a slight astringency: hence demulcent and pectoral; as the roots of the Comfrey (Fig. 764). The roots of Anchusa tinctoria (Alkanet), and Batschia canescens (used by the aborigines under the name of Puccoon), yield a red dye. — Several are showy plants; and some Heliotropiums are cultivated for the delicious fragrance of their blossoms.

Group 10. *Ovary free (superior), either compound or the carpels distinct, with several or numerous (rarely solitary) ovules in each cell. Fruit capsular, follicular, or baccate. Corolla regular; the stamens inserted upon its tube, as many as its lobes, and alternate with them.*

ORDER 95. HYDROPHYLLACEÆ. Herbs, usually with alternate and lobed or pinnatifid leaves; the flowers mostly in cymose clusters or unilateral racemes. — Calyx five-cleft, with the sinuses often appendaged, persistent. Corolla usually furnished with scales or honey-bearing grooves inside; the five stamens inserted into its base. Ovary with two parietal placentæ, which sometimes project into the cell and separate from the walls, often appearing like a kind of inner pericarp in the capsular fruit. Styles united into one. Seeds few, crustaceous. Embryo small, in cartilaginous albumen.

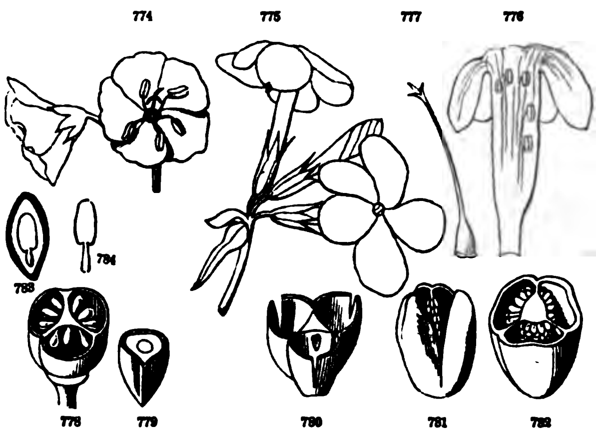
Ex. Hydrophyllum, Nemophila, and Phacelia; nearly all North American plants, some of them handsome in cultivation.

ORDER 96. HYDROLEACEÆ. Herbs, or slightly shrubby plants, with alternate simple leaves, often with spines in their axils. — Calyx five-cleft. Stamens five, inserted on the tube of the corolla. Ovary one-celled, with two large and projecting parietal placentæ, or two-celled by their meeting in the axis, with very numerous ovules: styles two, distinct! Fruit a capsule. Seeds small and numerous, albuminous, with a straight embryo.

Ex. Hydrolea, Nama. — Distinguished from all the related orders by the distinct styles; except Convolvulaceæ, from which they differ in their seeds and embryo.

FIG. 766. Hydrophyllum Virginicum. 767. A flower, nearly of the natural size. 768. Corolla laid open. 769. Capsule, with the persistent calyx and style. 770. Cross section of the same; the cavity filled by two seeds. 771. Magnified seed. 772. Section of the same. 773. Highly magnified embryo.

ORDER 97. POLEMONIACEÆ. Herbs, with alternate or opposite leaves, and panicled, corymbose, or clustered flowers. — Calyx five-cleft. Corolla with a five-lobed limb, imbricated or twisted in æstivation. Stamens five, often unequal. Ovary three-celled, with a thick axis, bearing few or numerous ovules: styles united into one: stigmas three. Capsule three-valved, loculicidal; the valves also usually breaking away from the thick three-cornered central column which bears the seeds. Embryo straight, in fleshy or horny albumen.



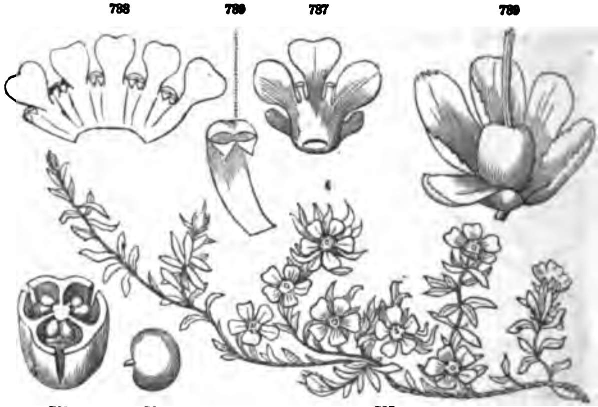
Ex. Polemonium (Greek Valerian), Phlox, Gilia. Chiefly American; many are very common ornamental plants.

ORDER 98. DIAPENSIACEÆ. Low, prostrate, and tufted suffruticose plants; with crowded and evergreen heath-like leaves, and solitary terminal flowers. — Calyx of

FIG. 774. Flowers of Polemonium. 775. Flowers of Phlox. 776. Corolla laid open, showing the stamens unequally inserted on its tube. 777. Pistil of the same. 778. Cross section of the capsule of Polemonium. 779. Cross section of a magnified seed. 783. Perpendicular section of the same. 784. Magnified embryo. 780. Cross section of the dehiscent capsule of Collomia. 781, 782. Capsule of Leptodactylon.

five imbricated sepals, persistent. Stamens five, with petaloid filaments, inserted on the throat of the five-lobed corolla: anthers transversely two-valved. Ovary three-celled, with several or many ovules in each cell: styles united into one. Capsule three-valved, loculicidal. Seeds pitted, amphitropous, albuminous. Embryo with a slender radicle, and very short cotyledons.

788 786 787 789



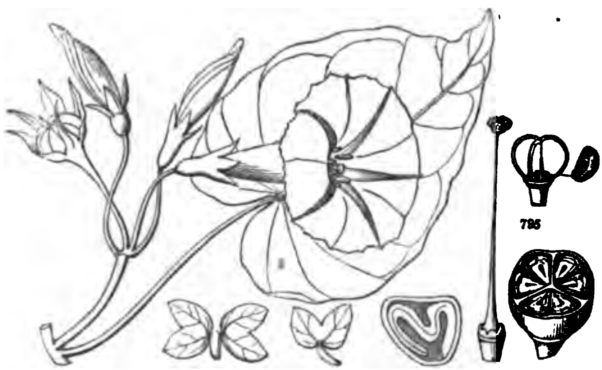
790 791 785

Ex. The order consists of Diapensia, of the colder parts of Europe and North America; and Pyxidanthera (Fig. 785), growing in the Pine-barrens of New Jersey, &c.

ORDER 99. CONVOLVULACEÆ. Twining or trailing herbs or shrubs, often with milky juice; the leaves alternate, and the flowers showy.—Calyx of five sepals, imbricated, or usually more or less united, persistent. Corolla plaited and twisted in æstivation (Fig. 218); the limb often entire. Stamens five, inserted on the tube of the corolla near the base. Ovary two to four-celled, with one or two erect ovules in each cell: styles united, or more or less

FIG. 785. Pyxidanthera barbulata, natural size. 786. Pistil, in fruit, and the persistent calyx, enlarged. 787. Corolla and stamens. 788. Same laid open. 789. A separate stamen magnified. 790. Section of the dehiscent capsule. 791. A seed.

distinct. Capsule two to four (or by obliteration one) celled; the valves falling away from the persistent dissepiments (septifragal). Seeds large, with a little mucilaginous albumen: embryo curved, and the foliaceous cotyledons crumpled.



795

792 798 797 796 793 794

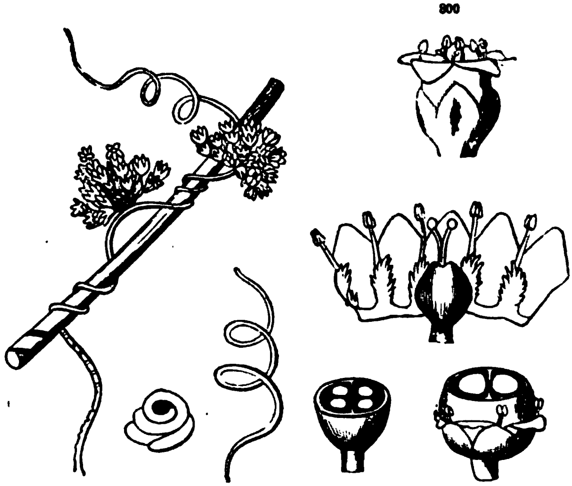
Ex. Convolvulus (Morning Glory, Bindweed). They all contain a peculiar strongly purgative resinous matter, which is chiefly found in the acrid, milky juice of their thickened or tuberous roots. Convolvulus Jalapa, and other Mexican species, furnish the *Jalap* of the shops. The more drastic *Scammony* is derived from the roots of C. Scammonia of the Levant. There is much less of this in those of Convolvulus panduratus (Mechameck, Man-of-the-Earth, Wild Potato-vine): while those of C. macrorhizus of the Southern States, which sometimes weigh forty to fifty pounds, are farinaceous, with so slight an admixture of the peculiar resin as to be quite inert; as is also the case with

FIG. 792. Convolvulus purpureus. 793. The pistil. 794. Section of the capsule, and of the two seeds in each cell. 795. Capsule (reduced in size), when the valves have fallen away from the dissepiments; and one of the seeds. 796. Magnified cross section of a seed. 797. Embryo, with the leaf-like two-lobed cotyledons spread out. 798. Same, with the two cotyledons separated and laid open.

the Batatas, the Sweet Potato, an important article of food. — To this family the following may be appended as sub-orders: —

1. DICHONDREÆ. Ovaries two to four, either entirely distinct or with their basilar styles united in pairs. — Creeping plants, with axillary and scape-like one-flowered peduncles. — *Ex.* Dichondra.

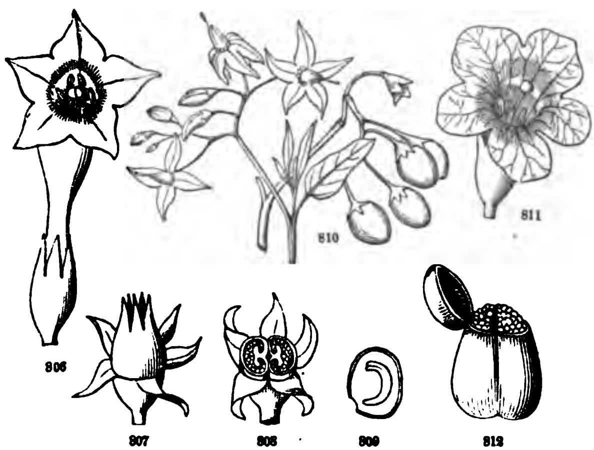
2. CUSCUTINEÆ. Ovary two-celled; the capsule opening by circumscissile dehiscence or bursting irregularly. Embryo filiform, and spirally coiled in fleshy albumen, destitute



of cotyledons (447)! — Parasitic, leafless, twining herbs, destitute of green color (64). Corolla usually furnished with fringed scales within, marcescent. — *Ex.* Cuscuta (Dodder).

FIG. 799. A piece of Cuscuta Gronovii, the common Dodder of the Northern United States, of the natural size. 800. A flower enlarged. 801. The same laid open. 802. Section of the ovary. 803. Section of the capsule and seeds. 804. The spiral embryo detached. 805. The same in germination.

ORDER 100. SOLANACEÆ. Herbs, or shrubby plants, with a watery juice, and alternate leaves. Inflorescence often supra-axillary: pedicels without bracts. — Calyx of four or five more or less united sepals, mostly persistent. Corolla regular, sometimes a little irregular, plaited in æstivation. Ovary two-celled, with the placentæ in the axis: styles and stigmas united into one. Fruit a many-seeded capsule or berry. Embryo mostly curved, in fleshy albumen.



Ex. Solanum (Potato), Nicotiana. The fruit of Datura is spuriously four-celled. — Distinguished from Scrophulariaceæ by their regular flowers and plaited æstivation. Stimulant narcotic properties pervade the order; the herbage and fruits of which are mostly deleterious, often violently poisonous, and furnishing some of the most active medicines; such as the Tobacco, the Henbane (Hyoscyamus

FIG. 806. Flower of Tobacco (Nicotiana Tabacum). 807. The capsule, dehiscent at the apex, with the persistent calyx. 808. Cross section of the same. 809. Magnified section of the seed of Solanum. 810. Flowers and berries of Solanum Dulcamara. 811. Flower of Hyoscyamus niger. 812. Fruit (pyxis, 428) of the same.

niger), the Belladonna (Atropa Belladonna), the Thorn-apple or Jamestown Weed (Datura Stramonium), and the Bittersweet (Solanum Dulcamara); the last only slightly narcotic. Yet the berries of some Solanums are eatable when cooked (as Tomatoes, the Egg-Plant, &c.), and the starchy tubers of the Potato are an important article of food. On the other hand, the fruits and seeds of Capsicum annuum (*Cayenne pepper*) are purely stimulant.

ORDER 101. GENTIANACEÆ. Herbs, with a watery juice; the leaves almost always opposite and entire. Flowers showy.—Calyx of usually four or five persistent, more or less united sepals. Corolla mostly twisted in æstivation; the stamens inserted on its tube. Ovary one-celled, with two parietal, but often introflexed, placentæ; styles united, or none. Capsule many-seeded. Seeds with fleshy albumen and a minute embryo.

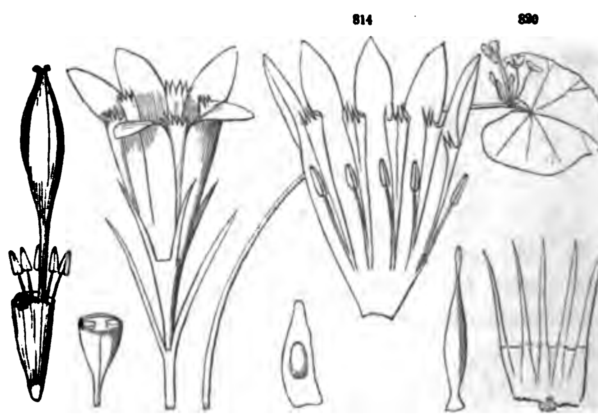


FIG. 813. Flower of Gentiana angustifolia. 814. Corolla, and 815, the calyx, laid open. 816. The pistil. 817. Cross section of the pistil, showing the parietal attachment of the ovules. 818. Ripe capsule of G. Saponaria, raised on a stipe: the persistent withering corolla, &c., torn away. 819. A magnified seed, with its large and loose testa. 820. Leaf of Limnanthemum (Villarsia), bearing the flowers on its petiole (277).

Ex. Gentiana, Sabbatia, Frasera (the American Columbo), Menyanthes; the latter (called Buck-Bean) differs from the rest of the order in its compound leaves, and a few other characters. — A pure bitter and tonic principle (*Gentianine*) pervades the whole order. Gentiana lutea of Middle Europe furnishes the officinal *Gentian*, for which almost any of our species may be substituted. Many are very ornamental plants.

ORDER 102. APOCYNACEÆ. Trees, shrubs, or herbs, with milky juice, and opposite entire leaves, without stipules. — Calyx five-cleft, persistent. Corolla five-lobed, twisted in æstivation. Filaments distinct; the anthers sometimes slightly connected. Ovaries two, distinct, or rarely united, but their styles or stigmas combined into one: in fruit usually forming two follicles. Seeds often with a coma, albuminous.

Ex. Apocynum (Dog's-bane, Fig. 821), Vinca (Periwinkle); and a great number of tropical shrubs and trees.

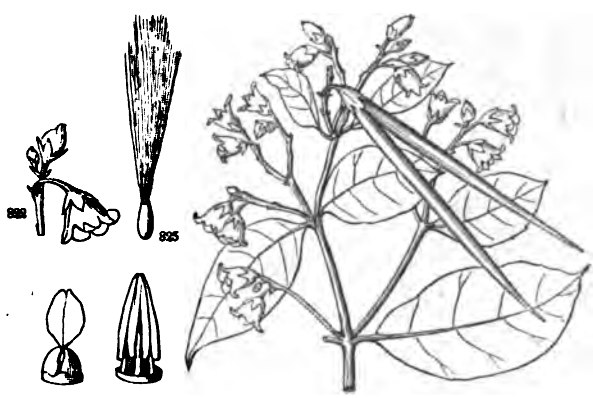


FIG. 821. Apocynum androsæmifolium. 822. Flower of the natural size. 823. Stamens with the anthers connivent around the pistils. 824. The pistils with their large common stigma. 825. Seed with its coma, or tuft of silky hairs.

In all, the juice is drastic or poisonous, and often yields *Caoutchouc;* which in Sumatra is obtained from Urceola elastica. The well known *Nux vomica* is the seed of Strychnos Nux-vomica of India. S. toxifera yields the famous *Woorari* poison of Guiana. One kind of *Upas* is obtained from the bark of the root of S. Tieute in Java. The poisonous principle in all these plants is an alkaloid, called *Strychnia.*

ORDER 103. ASCLEPIADACEÆ. Herbs or shrubs, with milky juice, and opposite entire leaves; differing from

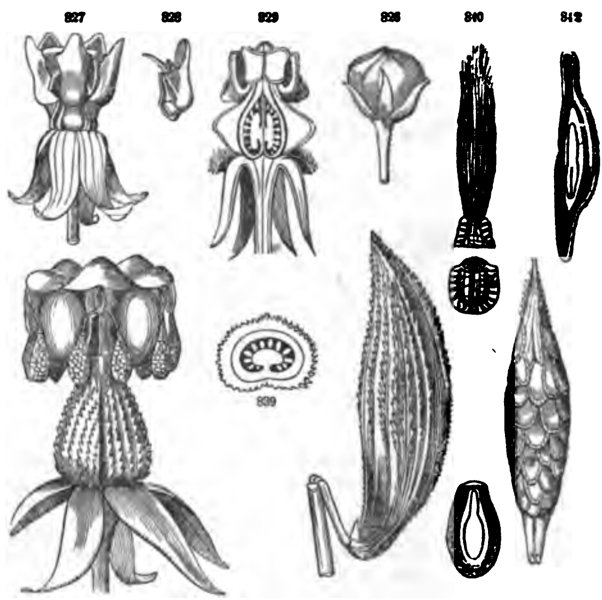
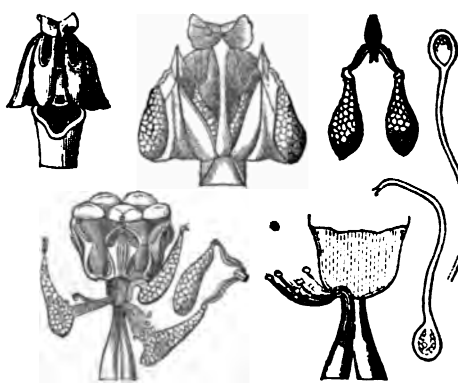


FIG. 826. Flower-bud of the common Milkweed (Asclepias Cornuti). 827. Expanded flower; the calyx and corolla reflexed; showing the stamineal crown. 828. One of the hooded appendages of the latter removed and seen sidewise, with its included process or horn. 829. A vertical section of a flower (the hooded appendages removed) through the tube of stamens, the thick stigma, ovaries, &c. 830. Flower with the calyx, and the fertilized enlarging ovaries, crowned with

the preceding order, as they do from all other Exogenous plants, by the peculiar connection of the stamens with the stigma, and the cohesion of the pollen into wax-like masses, which are attached in pairs to five glands of the stigma, and removed from the anther-cells usually by the agency of insects. Fruit consisting of two follicles. Seeds usually with a silky coma.

Ex. Asclepias (Milkweed, Wild Cotton). The juice of A. tuberosa (Pleurisy-root, Butterfly-weed) is not milky. In all it is bitter and acrid, and contains caoutchouc.

831 832 833 835



834 837 836

the large stigma common to the two, from the angles of the peltate summit of which the pairs of pollen-masses, detached from the anther cells, hang by their stalks or caudicle from a gland. 831. An anther, from which the hooded appendage is cut away. 832. One more magnified: its two pollen-masses still in the open cells, but attached by their stalks each to one of the glands, to which a pollen-mass of an adjacent stamen on each side is already similarly attached. 833. One of these pairs of pollen-masses separate. (834. Pollen-masses of Asclepias incarnata, connected by their emitted pollen-tubes (835, 836, much magnified) with the stigma. 837. Section through the stigma and into one of the styles, showing the course of the pollen tubes.) 838. Fruit (follicle) of the Common Milkweed. 839. Cross section of the last, in an early state. 839^{2}. Detached placenta in fruit, covered with seeds. 840. Seed (cut across), with its coma. 841. Section of the seed as it lies in 840, parallel with the cotyledons. 842. Vertical section of the seed perpendicular to the face of the cotyledons.

Group 11. *Ovary free (superior), two-celled, with one to three ovules in each cell: in fruit one or two-seeded. Corolla regular, sometimes nearly polypetalous, occasionally wanting. Stamens two, fewer than the lobes of the corolla, inserted on its tube or upon the receptacle. — Shrubs or trees.*

ORDER 104. JASMINACEÆ. Consists of a few Asiatic shrubs, with compound leaves and fragrant flowers; differing from the following by the imbricated or twisted æstivation of the hypocrateriform corolla, erect seeds, &c.

Ex. Jasminum, the Jessamine. — Cultivated for ornament, and for their very fragrant blossoms.

ORDER 105. OLEACEÆ. Trees or shrubs, with opposite leaves, either simple or pinnate. — Calyx persistent. Corolla four-cleft, or of four separate petals, valvate. Stamens mostly two. Fruit by suppression usually one-celled and one or two-seeded.

Ex. Olea (the Olive), and Chionanthus (Fringe-tree), where the fruit is a drupe. Syringa, the Lilac, which has a capsular fruit. Fraxinus, the Ash; where the fruit is a samara, the flowers are polyamous, and often destitute of petals. *Olive oil* is expressed from the esculent drupes of Olea Europæa. The bark, like that of the Ash, is bitter, astringent, and febrifugal. *Manna* exudes from the trunk of Fraxinus Ornus of Southern Europe, &c.

Division III. — APETALOUS EXOGENOUS PLANTS.

Corolla none; the floral envelopes consisting of a single series (calyx), or sometimes entirely wanting.

CONSPECTUS OF THE GROUPS AND ORDERS.

Group 1. Flowers perfect, with a conspicuous or colored calyx. Ovary several-celled and many-ovuled. Capsule or berry many-seeded. — Herbs or climbing shrubs.

106. ARISTOLOCHIACEÆ.

Group 2. Flowers perfect, or rarely polygamous, with a regular and often petaloid calyx. Ovules solitary in each ovary or cell. Embryo curved or coiled around mealy albumen, rarely in the axis. — Chiefly herbs.

* Ovary one-celled, with a single ovule.

107. CHENOPODIACEÆ. 109. AMARANTHACEÆ.
108. SCLERANTHACEÆ. 110. NYCTAGINACEÆ.
111. POLYGONACEÆ.

* * Ovary several-celled, consisting of a whorl of several one-ovuled carpels.

112. PHYTOLACCACEÆ.

Group 3. Flowers perfect, sometimes polygamous or diœcious, not disposed in aments, with a regular and more or less petaloid calyx. Ovary one-celled, or rarely two-celled, with one or few ovules in each cell: but the fruit one-celled and one-seeded. Embryo not coiled around albumen. — Trees or shrubs.

* Style or stigma one.

113. LAURACEÆ. 115. THYMELACEÆ.
114. SANTALACEÆ. 116. ELEAGNACEÆ.

* * Styles or stigmas two, divergent.

117. ULMACEÆ.

Group 4. Flowers perfect, entirely destitute of calyx as well as corolla. Embryo minute, inclosed in the sac of the amnios at the apex of the albumen. — Herbs or suffrutescent plants.

118. SAURURACEÆ.

Group 5. Flowers perfect or diclinous, frequently destitute of both calyx and corolla. — Submersed or floating aquatic herbs.

* Flowers monœcious. Fruit one-celled, one-seeded.

119. CERATOPHYLLACEÆ.

* * Flowers mostly perfect. Fruit four-celled, four-seeded.

120. CALLITRICHACEÆ.

* * * Flowers mostly perfect. Capsule several-celled, several-seeded.

121. PODOSTEMACEÆ.

Group 6. Flowers monœcious or diœcious, not amentaceous. Fruit capsular or drupaceous, with two or more cells, and one (or rarely two) seeds in each. — Herbs, shrubs, or trees.

122. EUPHORBIACEÆ. 123. EMPETRACEÆ.

Group 7. Flowers monœcious or diœcious; the sterile, and frequently the fertile also, in aments, or in heads or spikes. Ovary often two to several-celled, but the fruit always one-celled. — Trees, shrubs, or (only in Urticaceæ) herbs.

* Fruit drupaceous; the epicarp fibrous or coriaceous. Calyx adherent.

124. JUGLANDACEÆ.

* * Fruit a nut, involucrate. Calyx adherent.

125. CUPULIFERÆ.

* * * Fruit one-seeded, indehiscent. Fertile and sterile flowers both in aments, and entirely destitute of calyx.

126. MYRICACEÆ. 127. BETULACEÆ.

* * * * Fruit dehiscent, many-seeded. Seeds with a coma. Fertile and sterile flowers both in aments, and destitute of calyx.

128. SALICACEÆ.

* * * * * Fruit a nut or a two-celled and few-seeded capsule. Fertile and sterile flowers both in aments, and destitute of calyx.

129. BALSAMIFLUÆ. 130. PLATANACEÆ.

* * * * * * Fruit an achenium, often inclosed in a baccate calyx. Flowers variously disposed, sometimes collected in fleshy heads. — Juice milky, when trees or shrubs.

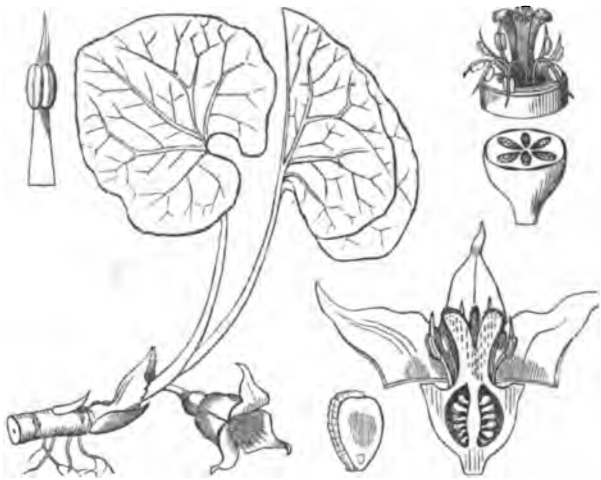
131. URTICACEÆ.

Group 1. *Flowers perfect, with a conspicuous or petaloid calyx: and an ovary of several cells with numerous ovules in each. — Herbs or climbing shrubs.*

ORDER 106. ARISTOLOCHIACEÆ. Herbaceous, or climbing shrubby plants; the alternate leaves often with leafy stipules. Flowers brown or greenish, usually solitary. — Calyx-tube more or less united with the ovary; the limb valvate. Stamens six to twelve, epigynous, or adherent to the base of the short and thick style. Stigmas radiate.

The ORDER RAFFLESIACEÆ, or RHIZANTHÆ, consisting of most remarkable fungus-like parasites (65, and Fig. 70) are to be placed somewhere in this vicinity.

Capsule or berry three to six-celled, many-seeded. Embryo minute, in fleshy albumen.



Ex. Asarum (Wild Ginger, Canada Snake-root, Fig. 843), Aristolochia (Virginia Snake-root); pungent, aromatic, or stimulant tonics; generally termed Snake-roots, being reputed antidotes for the bites of venomous snakes.

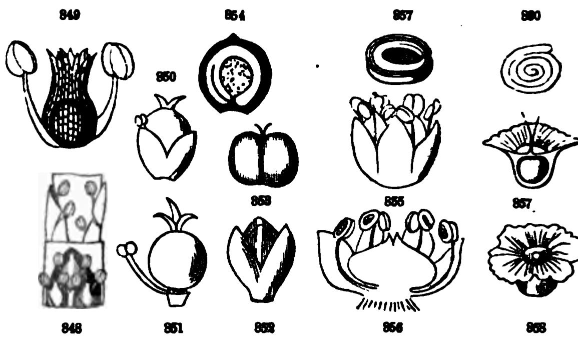
Group 2. *Flowers perfect, or rarely polygamous, with a regular and often petaloid calyx, and a one-celled and one-ovuled ovary, or else with a whorl of one-ovuled carpels. Embryo curved or coiled around the outside of mealy albumen, or spiral, rarely in the axis. — Mostly herbs.*

ORDER 107. CHENOPODIACEÆ. Chiefly weedy herbs, with alternate and more or less fleshy leaves, and

FIG. 843. Asarum Canadense. 844. Calyx displayed, and a vertical section through the rest of the flower. 845. Cross section of the ovary; the upper portion (from which the limb of the calyx is cut away) showing the stamens, the united styles, &c. 846. A separate stamen, enlarged. 847. Vertical section of a seed.

small flowers. — Calyx sometimes tubular at the base, persistent; the stamens as many as its lobes, or fewer, and inserted at their base. Ovary with a single ovule arising from its base. Fruit an utricle.

Ex. Chenopodium, Atriplex, Beta (the Beet), &c. Sea-side plants, or common weeds: some are pot-herbs, such as



Spinach; a few are cultivated for their esculent roots; as the Beet, which contains sugar. Soda is largely extracted from the maritime species, especially from those of Salsola and Salicornia (Samphire, Glass-wort). Chenopodium anthelminticum yields the *Worm-seed oil.*

ORDER 108. SCLERANTHACEÆ consists of one or two insignificant weeds (Scleranthus); which differ from Illecebraceæ in the absence of stipules, and from Chenopodiaceæ in the number of the stamens (commonly double the

FIG. 848. Part of the spike of Salicornia herbacea: the flowers placed three together in excavations of the stem, protected by a fleshy scale. 849. Separate flower. 850. A flower of Blitum, with its fleshy calyx and single stamen. 851. Same, more enlarged, with the thickened juicy calyx (852) removed. 853. The ripe fruit. 854. Same, divided vertically, showing the embryo coiled around the central albumen. 855. Flower of Chenopodium album (common Goosefoot). 856. Section of the same, more enlarged. 857. Section of the utricle and seed, showing the embryo. 858. Calyx of Salsola kali (Saltwort), in fruit, with its wing-like border. 859. Section of the same, bringing the ovary into view. 860. Its spirally coiled embryo.

lobes of the calyx), and their insertion on the throat of the indurated tube.

ORDER 109. AMARANTHACEÆ. Herbs, with opposite or alternate leaves; the flowers in heads, spikes, or dense clusters, imbricated with dry and scarious bracts which are usually colored. — Calyx of three to five sepals, which are dry and scarious, like the bracts. Stamens five or more, hypogynous, distinct or monadelphous: anthers frequently one-celled. — Otherwise nearly as in Chenopodiaceæ.

Ex. Amaranthus, Gomphrena, &c. — Weeds. A few Amaranths are cultivated for their dry and enduring richly-colored flowers.

ORDER 110. NYCTAGINACEÆ. Herbs or shrubs, with opposite leaves; distinguished by their tubular and infundibuliform calyx, the upper part of which resembles a corolla, and at length separates from the base, which hardens and incloses the one-celled and indurated achenium-like fruit. Stamens hypogynous.

Ex. Mirabilis (Four-o'clock); which has an involucre exactly like a calyx, while the latter resembles the corolla of a Morning Glory. Plants of warm latitudes.

ORDER 111. POLYGONACEÆ. Herbs with alternate leaves; remarkable for their stipules (ochreæ, 176), which usually form sheaths around the stems above the leaves, and for their orthotropous ovules. Stamens definite, inserted on the calyx. Fruit achenium-like, compressed or triangular. Embryo curved, or nearly straight, applied to the outside (rarely in the centre) of starchy albumen.

Ex. Polygonum, Rumex (Dock, Sorrel), Rheum (Rhubarb). The stems and leaves of Rhubarb and Sorrel are pleasantly acid: while several Polygonums (Knot-weed, Smart-weed, Water Pepper, &c.) are acrid or rubefacient.

The farinaceous seeds of P. Fagopyrum (the Buckwheat) are used for food. The roots of most species of ***Rhubarb***

864 863 861 862

are purgative: but it is not yet known what particular species of Tartary yield the genuine officinal article.

ORDER 112. PHYTOLACCACEÆ. Chiefly represented by the common Poke (Phytolacca decandra), and well distinguished by a compound ovary of ten confluent (one-seeded) carpels, the short styles or stigmas distinct; the fruit a flattened berry. — The root is acrid and emetic: yet the young shoots in the spring are used as a substitute for Asparagus. The berries yield a copious deep-crimson juice.

FIG. 861. Polygonum Pennsylvanicum. 862. Enlarged flower laid open. 863. Section of the ovary, showing the erect orthotropous ovule. 864. Section of the seed, showing the embryo, at one side of the albumen.

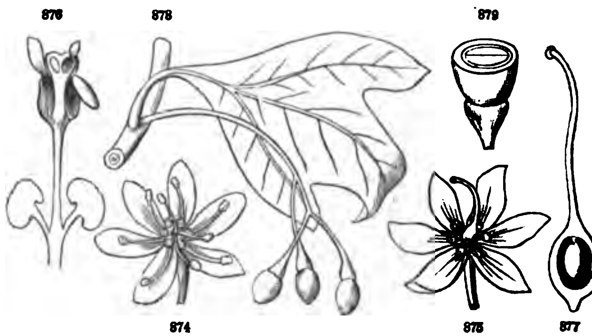
Group 3. *Flowers perfect, or sometimes polygamous, not disposed in aments, furnished with a regular and often petaloid calyx. Ovary one (rarely two) celled, with solitary ovules, or at least a single seed in each cell. Embryo not coiled around albumen.— Trees or shrubs, rarely herbs.*

ORDER 113. LAURACEÆ. Trees or shrubs, with alternate leaves, their margins entire. Flowers sometimes polygamo-diœcious.—Calyx of four to six somewhat united sepals, which are imbricated in two series, free from the ovary. Stamens definite, but usually more numerous than

FIG. 865, 866. Phytolacca decandra (Poke). 867. A flower. 868. Unripe fruit. 869. Cross section of the same, a little enlarged. 870. Magnified seed. 871. Section of the same across the embryo. 872. Vertical section, showing the embryo coiled around the albumen into a ring. 873. Magnified detached embryo.

the sepals, inserted on the base of the calyx: anthers two to four-celled, opening by recurved valves (347)! Fruit a berry or drupe, the pedicel often thickened. Seed with a large, almond-like embryo, destitute of albumen.

Ex. Laurus, Sassafras, Benzoin. All aromatic plants, almost every part abounding in warm and stimulant volatile



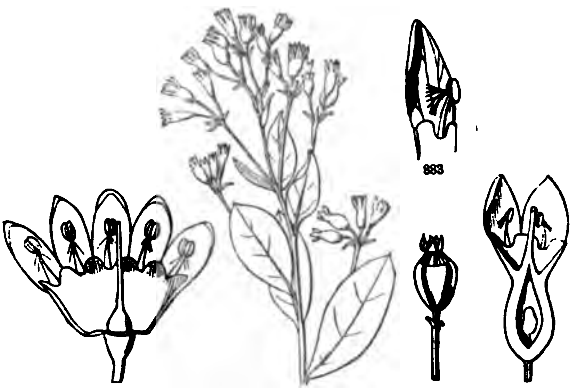
oil, to which their qualities are due. *Camphor* is obtained from Camphora officinarum of Japan, China, &c. *Cinnamon* is the bark of Cinnamomum Zeylanicum; *Cassia Bark*, of Cinnamomum aromaticum of China. The aromatic bark and wood, and the very mucilaginous leaves of our own Sassafras, are well known. Our Benzoin odoriferum is the Spice-wood, or Fever-bush. Laūrus nobilis is the true Laurel, or Sweet Bay. Persea gratissima, of the West Indies, bears the edible Avocado pear.

ORDER 114. SANTALACEÆ. Trees, shrubs, or sometimes herbs; with alternate entire leaves, and small (very rarely diœcious) flowers. — Calyx-tube adherent to the ovary; the limb four or five-cleft, valvate in æstivation; its base lined with a fleshy disk, the edge of which is often

FIG. 874. A staminate, and 875, a pistillate flower of Sassafras. 876. A stamen with its glands at the base: the anthers opening by two sets of valves. 877. Pistil; the ovary divided. 878. Branch in fruit. 879. Section of the drupe and seed.

lobed. Stamens as many as the lobes of the calyx, and opposite them, inserted on the edge of the disk. Ovules one to several. Fruit indehiscent, crowned with the limb of the calyx. Seed albuminous.

Ex. Comandra, Pyrularia, &c. The fragrant *Sandalwood* is obtained from several Indian and Polynesian species



881 880 884 882

of Santalum. The timber of our Nyssas (especially the Black Gum-tree, &c.) is remarkable for the toughness of the interlaced fibres, so that it is very difficult to split the trunks. The acid berries give the name of Sour Gum to N. capitata. The large seeds of Pyrularia oleifera (Buffalo-tree, Oil-nut) yield a copious fixed oil.

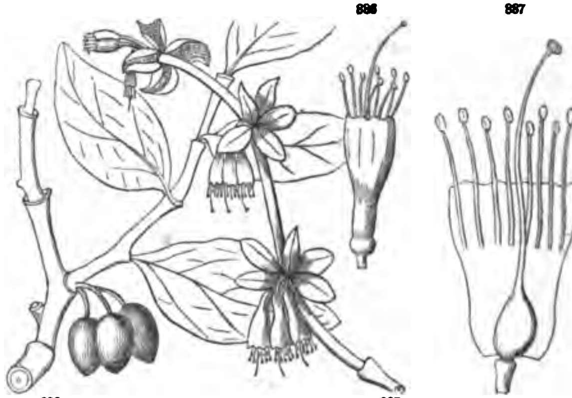
ORDER 115. THYMELACEÆ. Shrubby plants, with perfect flowers, and a very tough bark; distinguished from the preceding family by the tube of the petaloid calyx being free from the (one-ovuled) ovary; its lobes imbricated in æstivation, and the pendulous seed destitute of albumen.

FIG. 880. Branch of Comandra umbellata. 881. Enlarged flower laid open. 882. Vertical section of a flower. 883. One of the segments of the calyx, enlarged, showing the tuft of hairs which connects its surface with the anther! 884. The fruit, reduced in size.

Stamens often twice as many as the lobes of the calyx, inserted upon its tube or throat.

Ex. Daphne, &c., of Europe and Middle Asia; and Dirca (Leather-wood, Moose-wood, Wickopy), which is the only

886 887



888 885

North American genus. The tough bark is acrid, or even blistering, and is also useful for cordage. The reticulated fibres may be separated into a kind of lace in the Lagetta, or Lace-bark of Jamaica. The fruit of all the species is deleterious.

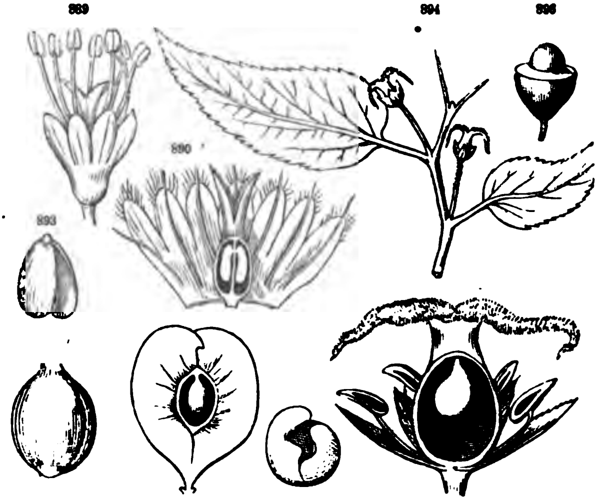
ORDER 116. ELEAGNACEÆ. Shrubs or small trees, with the flowers more commonly diœcious, the leaves either opposite or alternate; readily distinguished from the preceding by having the foliage and shoots covered with scurf, and by the ascending albuminous seed. The persistent tube of the calyx, although free from the ovary, becomes succulent, like a berry in fruit, and constricted at the throat, inclosing the crustaceous achenium!

Ex. Eleagnus, Shepherdia; cultivated for their silvery foliage. The fruit is sometimes eaten.

Fig. 885. Flowering branch of Dirca palustris. 886. A flower. 887. The same, laid open and enlarged. 888. Branch in fruit.

ORDER 117. ULMACEÆ. Trees or shrubs, with a watery juice, and alternate rough leaves, furnished with deciduous stipules. Flowers in axillary clusters or fascicles, rarely solitary, perfect or polygamous. — Calyx campanulate, four or five-cleft, free from the ovary; the lobes imbricated in æstivation. Stamens inserted on the base of the calyx, as many as its lobes and opposite them, sometimes more numerous. Ovary one or two-celled, with a single suspended ovule in each: styles or stigmas two. Fruit one-celled and one-seeded, either a samara or a drupe.

889 894 896



892 891 897 895

Ex. Ulmus, the Elm. — Celtis, the Nettle-tree, Hackberry, or Sugar-berry, is the type of the suborder CELTIDEÆ; which differs from the proper Elm tribe in its dru-

FIG. 889. Flower of the Slippery Elm. 890. Calyx laid open and the ovary divided vertically. 891. Fruit, the cell laid open to show the single seed. 892. The latter magnified. 893. Its embryo.

FIG. 894. Branch of Celtis Americana, in flower. 895. Enlarged flower divided vertically. 896. Drupe, the flesh divided to show the stone. 897. The coiled embryo.

paceous fruit, and curved embryo in fleshy albumen. The Elms are fine timber-trees: the inner bark yields an abundant mucilage in U. fulva, the well known Slippery Elm. The drupes of Celtis are sweet.

Group 4. ***Flowers perfect, destitute of calyx as well as corolla (achlamydeous). Embryo minute, included in he persistent sac of the amnios at the apex of the albumen! — Herbs or suffrutescent plants.***

FIG. 898. Saururus cernuus. 899. A separate flower, with its bract and a part of the axis, magnified. 900. A more magnified anther, disharging its pollen from one cell. 901. Cross section of the ovary. 902. Vertical section of one of the carpels in fruit, and of the contained seed, with the sac at the extremity of the albumen, containing the minute embryo. 903. A seed. 904. Same with the outer integument (testa) removed, showing the sac of the amnios. 905. The latter highly magnified. 906. Section of the same, showing the inclosed heart-shaped embryo.

ORDER 118. SAURURACEÆ. Herbs (growing in swampy places), with the stems jointed at the nodes; the leaves alternate, entire, with somewhat sheathing petioles; the flowers in racemes or spikes. Stamens definite. Ovary composed of three to five, more or less united, few-ovuled carpels, with distinct styles or stigmas. Capsule or berry with usually a single seed in each cell. Embryo heart-shaped.

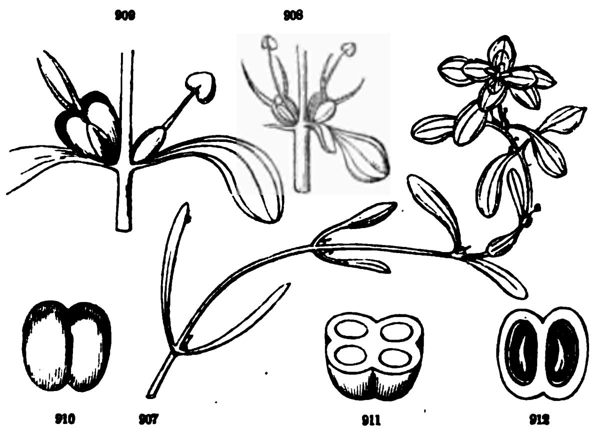
Ex. Saururus (Lizard's-tail). — Slightly pungent plants.

Group 5. *Submersed or floating aquatic herbs. Flowers either perfect or diclinous, bracteate or involucrate, but commonly destitute of calyx as well as corolla. Ovary simple, or of two to four combined carpels.*

ORDER 119. CERATOPHYLLACEÆ consists of the single genus Ceratophyllum (growing in ponds and streams in many parts of the world); distinguished by the whorled and dissected leaves with filiform segments; the flowers monœcious, and sessile in the axil of the leaves; the stamens indefinite, with sessile anthers; and the simple one-celled ovary, which forms a beaked achenium in fruit, containing an orthotropous suspended seed, with four cotyledons! and a manifest plumule.

ORDER PIPERACEÆ, a chiefly tropical order of Group 4; differing from Saururaceæ principally in the one-celled simple ovary, with a solitary ovule (fruit a berry), extrorse anthers; the leaves often opposite or whorled; the jointed stems sometimes woody, but scarcely exhibiting annual layers. They all possess stimulant, aromatic, and pungent qualities; the common *Pepper* (the dried berries of the Indian Piper nigrum) representing the ordinary properties of the order. The intoxicating *Betel* of the Malays consists of the leaves of Piper Betle. The *Ava* of the Society and Sandwich Islands, from which an inebriating drink is made, is Piper methysticum.

ORDER 120. CALLITRICHACEÆ, formed of the (European and North American) genus Callitriche; aquatic annuals, with opposite entire leaves; the axillary flowers (either perfect or monœcious) with a two-leaved involucre,



but entirely destitute of calyx and corolla; the stamen one (or rarely two), hypogynous, with a slender filament, and a reniform one-celled anther; the ovary four-lobed, four-celled, indehiscent in fruit; the seeds albuminous.

ORDER 121. PODOSTEMACEÆ comprises a few (American and Asiatic) aquatics, with the aspect of Mosses or Hepaticæ; their small flowers arising from a kind of spathe; the calyx often entirely wanting; the stamens frequently reduced to one, or two and monadelphous; the ovary two or three-celled, with distinct styles; in fruit forming a ribbed capsule, containing numerous exalbuminous seeds attached to a central column. — *Ex.* Podostemum.

FIG. 907. Callitriche verna, about the natural size. 908. Perfect flowers, magnified. 909. A staminate and a pistillate flower, magnified. 910. The fruit. 911. Cross section of the fruit. 912. Vertical section through the pericarp, seeds, and embryo.

Group 6. ***Flowers monœcious or diœcious, sometimes furnished with petals as well as calyx, but often destitute of both, not amentaceous. Ovary two to several-celled, with one or two ovules in each cell. Fruit capsular or drupaceous, with two or more cells.***

Order 122. EUPHORBIACEÆ. Herbs, shrubs, or even trees, often with a milky juice: in northern temperate climes chiefly represented by the genus Euphorbia (Fig. 913); which is remarkable for having numerous staminate flowers, reduced to a single stamen (p. 204), inclosed in an involucre along with one pistillate flower reduced to a com-

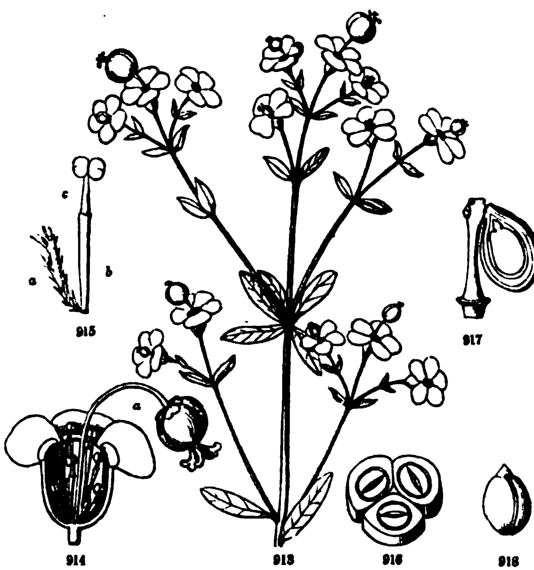


FIG. 913. Branch of Euphorbia corollata; the involucres resembling a corolla. 914. Vertical section of an involucre (somewhat enlarged), showing a portion of the staminate flowers surrounding the pistillate (*a*), which in fruit is raised on a slender pedicel. 915. One of the staminate flowers enlarged, with its bract *a* : *b*, the pedicel, to which the single stamen, *c*, is attached by a joint; there being no trace of floral envelopes (312). 916. Cross section of the tricoccous fruit. 917. Vertical section of one of the cocci (the two others having fallen away from the axis), and of the contained seed; showing the embryo lengthwise. 918. A seed.

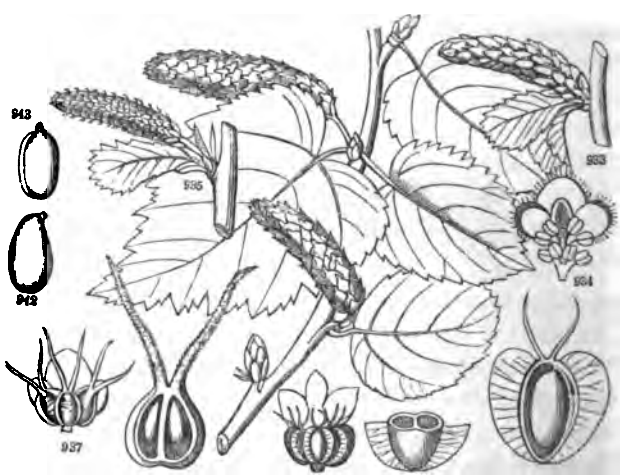
in aments. Sterile flowers consisting of two or more stamens in the axil of a bract, forming a slender ament. Fertile flowers consisting of a one-celled and one-ovuled ovary, surrounded by hypogynous scales, placed in the axil of a bract, forming an oval or cylindrical ament: stigmas two. Fruit dry or drupaceous. Albumen none.

Ex. Myrica Gale (Sweet Gale) is somewhat aromatic; as is Comptonia asplenifolia, the Sweet Fern. The drupes of M. cerifera (our Candleberry) yield a natural wax.

ORDER 127. BETULACEÆ. Trees or shrubs, with alternate and simple straight-veined leaves, and deciduous

936

943



942

938 939 940 941

FIG. 933. Ament of staminate flowers of Betula pumila. 934. One of the three-lobed scales of the same enlarged, showing the flowers (stamens) on the inner side. 935. Ament of pistillate flowers. 936. Branch in fruit. 937. One of the scales with its three flowers (pistils) seen from within. 938. Magnified section of one of the two-celled pistils, displaying the ovule suspended from the summit of each cell. 939. The pistils (with their subtending bract) in a more advanced state. 940. Magnified cross section of one of the ovaries. 941. The mature fruit, with the cell divided vertically; the single seed occupying the cavity; a mere trace of the other cell being visible. 942. The seed removed. 943. The embryo.

stipules. — Flowers monœcious; those of both kinds in aments and commonly achlamydeous, placed three together in the axil of each three-lobed bract. Stamens definite. Ovary two-celled, each cell one-ovuled: styles or stigmas distinct. Fruit membranaceous or samara-like, one-celled and one-seeded, forming with the three-lobed bracts a kind of strobile. Albumen none.

Ex. Betula (the Birch), Alnus (Alder). The bark is sometimes astringent, or with an aromatic flavor. The peculiar odor of Russia leather is said to be owing to a pyroligneous oil obtained from the European Betula alba.

ORDER 128. SALICACEÆ. Trees or shrubs, with alternate simple leaves, furnished with stipules. Flowers diœcious; both kinds in aments, and destitute of floral en-

944 945 946

948 947 949

FIG. 944. The sterile, and 947, the fertile ament of Salix vitellina, the common Willow. 945. Bract with a staminate flower. (946. Bract and staminate flower of Salix monandra, the stamens united into one body.) 948. Bract and fertile flower. 949. Pod and seeds.

velopes (achlamydeous), one under each bract. Stamens two to several, sometimes monadelphous. Ovary one-celled or imperfectly two-celled, many-ovuled! Styles or stigmas two, often two-cleft. Fruit a kind of follicle, opening by two valves. Seeds numerous, ascending, furnished with a silky coma! Albumen none.

Ex. Salix (Willow), and Populus (the Poplar). Trees with light and soft wood: the slender flexible shoots of several Willows are employed for wicker-work. The bark is bitter and tonic; containing a peculiar substance (*Salicine*), which possesses febrifugal qualities. The buds of some Poplars exude a fragrant balsamic resin.

ORDER 129. BALSAMIFLUÆ consists of a single genus of three or four species (natives of Eastern India, the Levant, and North America): which are trees, with alternate palmately-lobed leaves, deciduous stipules; the monœcious flowers in rounded aments or heads, destitute of floral envelopes; the indurated capsules and scales forming a kind of strobile; the former two-celled, two-beaked, opening between the beaks, several-seeded: the seeds with a little albumen.

Ex. Liquidambar, or Sweet-Gum: so called from the fragrant balsam or *Storax* it exudes.

ORDER 130. PLATANACEÆ consists of the single genus Platanus (Plane-tree, Button-ball), with one Asiatic and one or more North American species: which are fine trees, with a watery juice, alternate palmately-lobed leaves, with sheathing stipules. Flowers in globose amentaceous heads; both kinds destitute of floral envelopes. Fruit a one-seeded club-shaped little nut, the base furnished with bristly hairs. Seed albuminous.

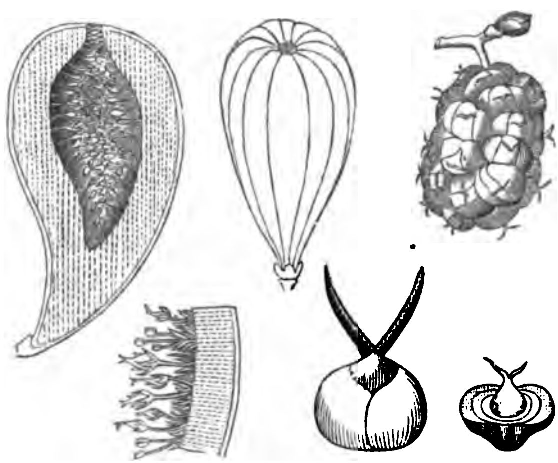
ORDER 131. URTICACEÆ. Trees or shrubs with milky juice, or herbs with a watery juice. Leaves often

stipulate. — Flowers monœcious, diœcious, or polygamous, sometimes collected in aments or fleshy heads, furnished with a regular calyx. Stamens definite. Ovary free from the calyx, simple, with a solitary ovule. Fruit an achenium or utricle, often inclosed in a fleshy or baccate calyx. — The order comprises the following principal divisions: —

1. ARTOCARPEÆ; which are trees or shrubs with a milky or yellow juice; the flowers mostly aggregated into fleshy heads, and forming a compound baccate fruit, or else inclosed in a dry or succulent involucre. Albumen none. — *Ex.* Artocarpus (the Bread-fruit), Antiaris (Upas): all tropical.

2. MOREÆ; which are shrubs or trees, very rarely herbs, with a milky juice; the staminate and pistillate flowers

951 950 953



952 954 955

FIG. 950. A fig; of which 951 is a section; and 952 a more magnified slice, to show the flowers which line the cavity.

FIG. 953. A young mulberry. 954. A magnified flower, with its fleshy envelopes; which in 955 are cut across.

either in separate aments or spikes, or often intermixed and included in the same hollow and closed fleshy receptacle (as in the Fig): the calyx, &c., becoming succulent, and forming a compound fruit. Seeds albuminous. — *Ex.* Morus (the Mulberry), Maclura (the Osage Orange), Ficus (the Fig): nearly all tropical.

3. Urticeæ; which are herbs in colder countries, but often shrubs or trees in the tropics, with a watery juice, often with stinging hairs; the flowers mostly loose, spicate, or panicled; the achenium usually surrounded by a dry and membranous calyx. Embryo straight, in fleshy albumen. — *Ex.* Urtica (the Nettle), Parietaria.

4. Cannabineæ; which are annual erect herbs, or perennial twining plants, with a watery juice; the staminate flowers racemose or panicled; the pistillate glomerate, or imbricated with bracts, and forming a kind of strobile-like ament. Embryo curved: albumen none. — *Ex.* Cannabis (the Hemp), Humulus (the Hop): natives of northern temperate regions.

The fruit in this large and polymorphous family is mostly innocent and edible, at least when cooked; while the milky juice is more or less acrid, or deleterious. It also abounds in *Caoutchouc;* much of which is obtained from some South American trees of this order, and from Ficus elastica in Java. In one instance, however, the milky juice is perfectly innocent; that of the famous Cow-tree of South America, which yields copiously a rich and wholesome milk. One of the most virulent of poisons, the *Bohon Upas*, is the concrete juice of Antiaris toxicaria of the Indian Archipelago. The Bread-fruit is the fleshy receptacle and multiple fruit (428) of Artocarpus. *Fustic* is the wood of the South American Morus tinctoria. The resin called *Gum Lac* exudes and forms small grains on the branches of the celebrated Banyan-tree (Ficus Indica, Fig. 65). Nettles

are remarkable for their stinging venomous hairs, and tough fibres of the stem, which, as in those of Hemp, are used for cordage. The leaves of the Hemp are stimulant and narcotic, and are extensively used in the East for intoxication. *Hops* are the catkins of Humulus Lupulus; the bitter and sedative principle chiefly resides in the yellow grains that cohere to the scales and cover the fruit. The Caoutchouc from Java is yielded by Ficus elastica.

Subclass II. — Gymnospermous Exogenous Plants.

Ovules, and consequently the seeds, naked, that is, not inclosed in an ovary (519); the carpel being represented either by an open scale, as in Pines; or by a more evident leaf, as in Cycas; or else wanting altogether, as in the Yew.

Order 132. CONIFERÆ. Trees or shrubs, with branching trunks, abounding in resinous juice (the wood chiefly consisting of a tissue somewhat intermediate between ordinary woody fibre and vessels, which is marked with circular disks); the leaves mostly evergreen, scattered or fascicled, usually rigid and needle-shaped or linear, entire. Flowers monœcious or diœcious, commonly amentaceous. Staminate flowers consisting of one or more (often monadelphous) stamens, destitute of calyx or corolla, arranged on a common rachis so as to form a kind of loose ament. — The particular structure of the flowers and fruit varies in the subordinate groups chiefly as follows:

1. Abietineæ. Fertile aments formed of imbricated scales; which are the flat and open carpels, and bear a pair of ovules adherent to their base, with the foramen turned downwards. Scales subtended by bracts. Fruit a strobile or cone (429). Integument of the seed coriaceous

or woody, more or less firmly adherent to the scale. Embryo in the axis of fleshy and oily albumen, with two to fifteen cotyledons. — *Ex.* Pinus (the Pine), Abies (the Fir or Spruce), &c.

2. Cupressineæ. Fertile aments of few scales crowded on a short axis, or more numerous and peltate, not bracteate; the ovules one or two or numerous, borne on the base

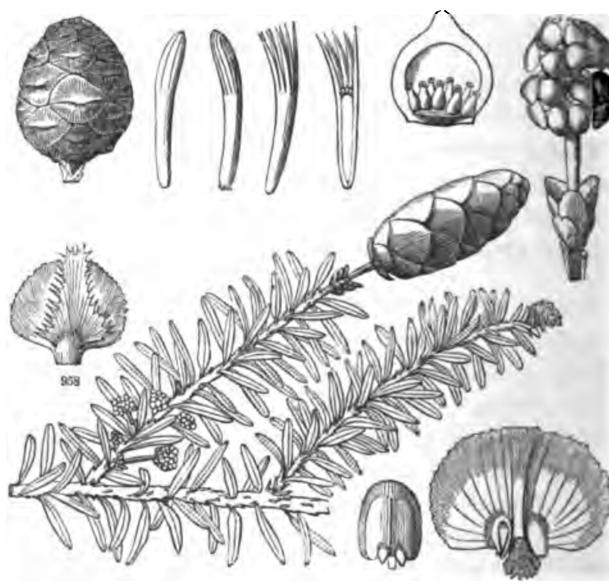


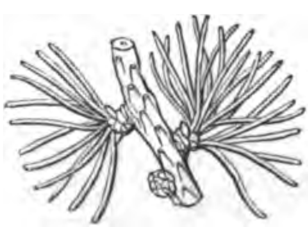
FIG. 956. Branch of Abies Canadensis (Hemlock Spruce), with lateral staminate flowers; and a fertile strobile. 957. Staminate ament, magnified. 958. Carpellary scale of a fertile ament, with its bract. 959. Similar fertile scale, more magnified and seen from within; showing the two ovules adherent to its base: one of them (the left) laid open. 960. The scale in front, nearly of the natural size, its inner surface occupied by the two seeds. 962. Polycotyledonous embryo of Abies and Cypress. 963. Vertical section of the same. 961. Strobile of Taxodium distichum (suborder Cupressineæ). 964. Carpellary scale of Cupressus sempervirens (the true Cypress), seen from within, and showing the numerous orthotropous ovules that stand on its base.

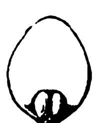
of the scale, erect (the foramen looking towards its apex). Fruit an indurated strobile, or fleshy and with the scales concreted, forming a kind of drupe. Integument of the seed membranous or bony. Cotyledons two or more. — Anthers of several parallel cells, placed under a shield-like connectivum. — *Ex.* Cupressus (Cypress), Taxodium (American Cypress), Juniperus (Juniper, Red Cedar).

3. TAXINEÆ. Fertile flowers solitary, terminal, consisting of an ovule, which is mostly surrounded by a fleshy disk; in fruit forming a kind of drupe. There is consequently no strobile, and no carpellary scales. Embryo with two cotyledons. — *Ex.* Taxus (the Yew), Torreya.

It is unnecessary to specify the important uses of this large and characteristic family, which comprises the most important timber-trees of cold countries, and also furnishes resinous products of great importance, such as *turpentine*, *resin*, *pitch*, *tar*, *Canada balsam* (obtained from the Balsam Fir), &c. The terebinthine *Juniper berries* are the fruit of Juniperus communis. The Larch yields *Venetian turpentine.* The powerful and rubefacient *Oil of Savin* is derived from J. Sabina of Europe: for which our J. Virginiana (Red Cedar) may be substituted. — The leaves of the Yew are narcotic and deleterious. The bark of Hemlock and Larch is used for tanning.

965



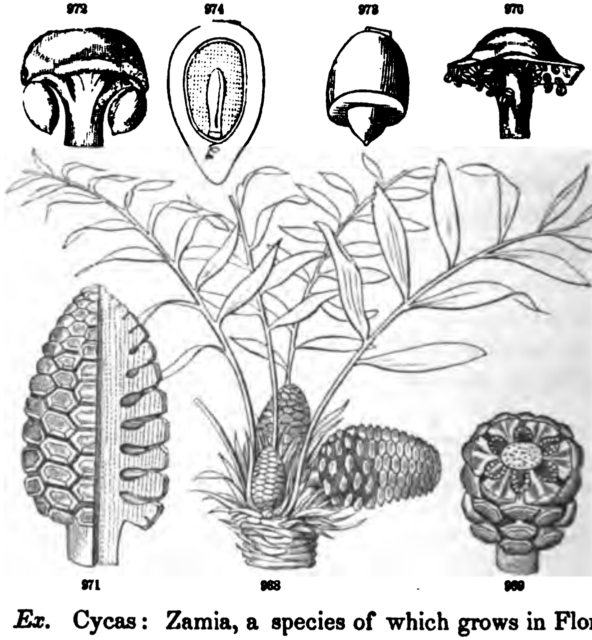


966 a 967 a

FIG. 965. Branch of a Larch with fascicled leaves. 966. One of the carpellary scales, bearing a pair of ovules at the base. 967. The same in fruit, reduced in size; one of the winged seeds still attached; the other (*a*) separated.

ORDER 133. CYCADACEÆ are tropical plants, with an unbranched cylindrical trunk, increasing, like Palms, by a single terminal bud; the leaves pinnate and their segments rolled up from the apex (circinate) in vernation in the manner of true Ferns. Flowers diœcious; the staminate in a strobile or cone; the pistillate also in strobiles, or else (in Cycas) occupying contracted and partly metamorphosed leaves; the naked ovules borne on its margins.

972 974 973 970



971 968 969

Ex. Cycas: Zamia, a species of which grows in Florida; the stem of which does not rise much above the

FIG. 968. Zamia integrifolia (the *Coontie* of Florida). 969. Section of the sterile ament. 970. One of its scales detached, bearing scattered anthers. 971. Fertile ament, from which a quarter-section is removed. 972. A pistillate flower, consisting of two ovules pendent from the thickened summit of the carpellary scale. 973. A drupaceous seed, from which a part of the pulpy outer portion is removed. 974. Vertical section through the seed (of the natural size), showing the pulpy outer coat, the hard inner integument, the albumen, and the embryo.

ground. — A kind of *Arrow-root* is obtained from these thickened stems; and a sort of *Sago* from the trunk of Cycas.

Class II. — Endogenous or Monocotyledonous Plants.

Stem not distinguishable into bark, pith, and wood; but the latter consisting of bundles of fibres and vessels irregularly imbedded in cellular tissue; the rind firmly adherent; no medullary rays, and no appearance of concentric layers: increase in diameter effected by the deposition of new fibrous bundles which descend in the central part of the stem, within the old (122). Leaves seldom falling off by an articulation, commonly sheathing at the base, usually alternate, entire, and with simple parallel veins (nerved). Floral envelopes when present mostly in threes; the calyx and corolla frequently undistinguishable (286). Embryo with a single cotyledon; or if the second is present, it is much smaller than the other and alternate with it (444).

Conspectus of the Groups and Orders.

Group 1. Flowers on a spadix, furnished with a double perianth (calyx and corolla). Ovary one to three-celled, with a single ovule in each cell. — Trees with unbranched columnar trunks.

134. Palmæ.

Group 2. Flowers on a spadix; with the perianth simple, scale-like, or commonly altogether wanting. — Chiefly herbs.

135. Araceæ. 137. Typhaceæ.
136. Lemnaceæ. 138. Naiadaceæ.

Group 3. Flowers not spadiceous, furnished with a double perianth (calyx and corolla). Ovaries several, distinct or sometimes united, free. — Aquatic herbs.

139. Alismaceæ.

Group 4. Flowers with a simple or double perianth, adherent to the ovary (ovary inferior), either completely or partially. — Herbs.

* Perianth regular. Ovary one-celled, with parietal placentæ, or rarely three to six-celled, with the placentæ in the axis.

140. Hydrocharidaceæ. 141. Burmanniaceæ.

* * Perianth irregular. Ovary one-celled, with parietal placentæ. Stamens one or two, adherent to the style (gynandrous).

142. Orchidaceæ.

* * * Perianth irregular. Ovary three-celled. Perfect stamens usually one.

143. Zingiberaceæ. 144. Cannaceæ.
145. Musaceæ.

* * * * Perianth regular, or sometimes a little irregular. Ovary three-celled, many ovuled (in Tillandsia free, in Lophiola nearly so). Stamens either three or six.

146. Bromeliaceæ. 148. Hæmodoraceæ.
147. Amaryllidaceæ. 149. Iridaceæ.

* * * * * Perianth regular. Ovary three-celled, with one or two ovules in each. Flowers diœcious. Stamens six.

150. Dioscoreaceæ.

Group 5. Flowers with a regular perianth, which is more or less petaloid (the two series when present are similar), or rarely glumaceous, and free from the ovary. Embryo inclosed in albumen.

151. Smilaceæ. 153. Pontederiaceæ.
152. Liliaceæ. 154. Melanthaceæ.
155. Juncaceæ.

Group 6. Flowers with a double or imbricated perianth: the exterior herbaceous or glumaceous; the inner petaloid, free from the one to three-celled ovary. Seeds orthotropous; the embryo at the extremity of the albumen farthest from the hilum.

156. Commelynaceæ. 157. Xyridaceæ.
158. Eriocaulonaceæ.

Group 7. Flowers imbricated with bracts (glumes) and disposed in spikelets; the proper perianth none or rudimentary. Ovary one-celled, one-ovuled. Embryo at the extremity of the albumen next the hilum.

159. Cyperaceæ. 160. Gramineæ.

Group 1. *Flowers on a simple or usually branched spadix, furnished with a double perianth (calyx and corolla). Ovary one to three-celled, with a single ovule in each cell. — Trunks cylindrical and unbranched.*

ORDER 134. PALMÆ. Chiefly trees, with unbranched cylindrical trunks, growing by a terminal bud. Leaves large, clustered, fan-shaped or pinnated, plaited in vernation. Flowers small, perfect or polygamous; the stamens usually as many as the petals and sepals together. Fruit a drupe or berry. Seeds with cartilaginous albumen, often hollow; the embryo placed in a small separate cavity.

Ex. Palms, the most majestic race of plants within the tropics, and of the highest value to mankind, are scarcely found beyond the limits of these favored regions. The Date-tree (Phœnix dactylifera, the leaves of which are the *Palms* of Scripture), a native of Northern Africa, endures the climate of the opposite shore of the Mediterranean: while in the New World, Chamærops Palmetto (Fig. 98[2]),

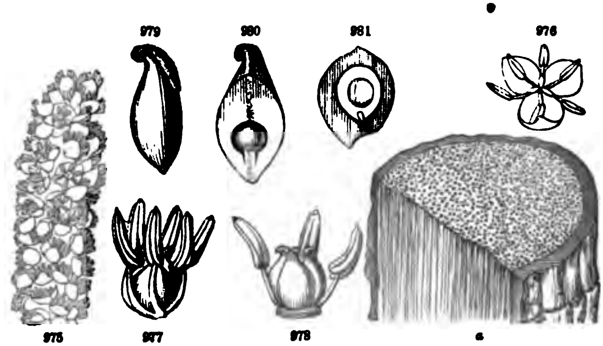


FIG. 975. Branch of the inflorescence of Chamærops Hystrix (Blue Palmetto). 976. A sterile flower. 977. Perfect flower, with the calyx and corolla removed. 978. Same, with three of the stamens removed, so as more distinctly to show the three somewhat united carpels. 979. One of the carpels enlarged, seen laterally. 980. Same, with a section of its inner face, showing the ovule or young seed. 981. Vertical section of a young cocoa-nut, showing the hollow albumen; and also the small embryo in a separate little cavity. *a*. Section of a Palm-stem.

the only arborescent species of the United States, and one or two low Palms with a creeping caudex (Dwarf Palmettoes), extend from Florida to North Carolina. — Our limits will not suffice for an enumeration of the economical uses of Palms: which afford food and raiment, wine, oil, wax, flour, sugar, salt, thread, weapons, utensils, and habitations. The Cocoa-nut (Cocos nucifera) is perhaps the most important as well as the most widely diffused species. Besides its well known fruit, and the beverage it contains, the hard trunks are employed in the construction of huts; the terminal bud (as in our Palmetto and other Cabbage Palms) is a delicious article of food; the leaves are used for thatching, for making hats, baskets, mats, fences, for torches, for writing upon; the stalk and midrib for oars; their ashes yield abundance of potash; the juice of the flowers and stems (replete with sugar, which is sometimes separated under the name of *Jagery*) is fermented into a kind of wine, or distilled into *Arrack;* from its spathes (as from some other Palms), when wounded, flows a grateful laxative beverage, known in India by the name of *Toddy;* the rind of the fruit is used for culinary vessels; its tough, fibrous, outer portion is made into very strong cordage (*Coir rope*); and an excellent fixed oil is copiously expressed from the kernel. *Sago* is procured from the trunks of many Palms, but chiefly from species of Sagus of Eastern India. *Canes* and *Rattans* are the slender, often prostrate, stems of species of Calamus.

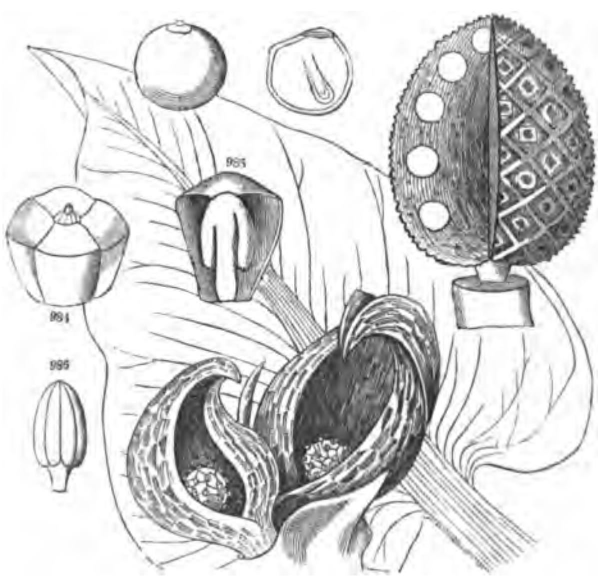
Group 2. *Flowers mostly on a spadix, with the perianth either wanting or scale-like, rarely regular and simple (calyx). Chiefly aquatic herbs.*

ORDER 135. ARACEÆ. Herbs, with a fleshy cormus or rhizoma, occasionally shrubby or climbing plants in the tropics; the leaves sometimes compound or divided, fre-

quently with more or less reticulated veins. Spathe (often naked at the extremity) usually surrounded by a spadix. Flowers commonly monœcious, and destitute of envelopes. — Ovary one to several-celled, with one or more ovules. Fruit a berry. Seeds mostly with fleshy albumen.

Ex. Arum, Calla, Symplocarpus (Skunk-Cabbage), Orontium, Acorus (Sweet Flag): the three latter bear flowers furnished with a perianth. — All are endowed with an acrid volatile principle, which is merely pungent and aromatic in *Sweet Flag* (Acorus Calamus). The roots and seeds of

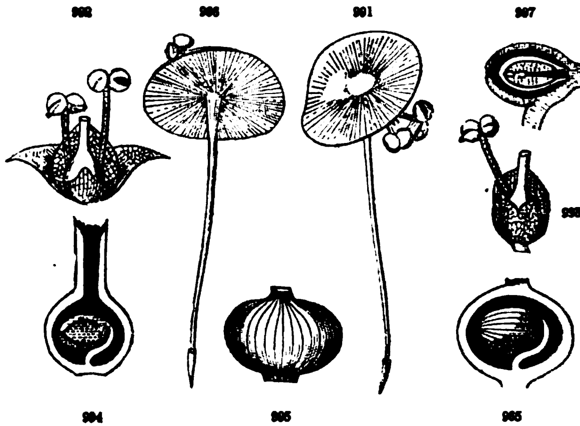
988 989 987



983 982

FIG. 982. Young leaf, and 983, spathes and flowers of Symplocarpus fœtida. 984. A separate flower. 985. A sepal and stamen seen from within. 986. An anther seen from the front. 987. The spadix or collective head in fruit; a quarter-section removed, showing sections of the immersed seeds. 988. A seed detached, of the natural size. 989. Section of the seed, with its large globular embryo and plumule: in this plant there is no albumen.

Skunk-Cabbage (the offensive odor of which is indicated by its popular name) are antispasmodic.



ORDER 136. LEMNACEÆ, consisting chiefly of Lemna (Duckweed, or Water Flax-seed, Fig. 990); floating plants, with their roots arising from the bottom of a flat frond, and hanging loose in the water; their flowers produced from the margin of the frond, bursting through a membranous spathe; the sterile, of one or two stamens; the fertile, of a one-celled ovary; in fruit an utricle: they are a kind of minute and greatly reduced Araceæ.

ORDER 137. TYPHACEÆ consists of two genera; namely, Typha (the Cat-tail), and Sparganium (Burr-reed), of no important use; they are somewhat intermediate between Araceæ and Cyperaceæ.

ORDER 138. NAIADACEÆ, or FLUVIALES. Water-

FIG. 990. Whole plant of Lemna minor, magnified, bearing a staminate monandrous flower. 991. An individual with a diandrous perfect flower; which at 992 is seen separate, with its spathe, highly magnified. 993. Flower of Lemna gibba, much magnified. 994. Vertical highly magnified section of the pistil and the contained ovule of Lemna minor. 995. The fruit, and 996, its section, showing the seed. 997. Section through the highly magnified seed and large embryo.

plants, with cellular leaves, and sheathing stipules: the flowers inconspicuous, sometimes perfect. — Perianth simple or none. Stamens definite. Ovaries solitary, or two to four and distinct, one-seeded. Albumen none. Embryo straight or curved. *Ex.* Potamogeton (Pond-weed), Najas, Ruppia, Zostera; the latter two in salt or brackish water.

Group 3. *Flowers not on a spadix, furnished with a double perianth (calyx and corolla). Ovaries three to six, or numerous, free, distinct, or more or less united. — Aquatic or swampy herbs.*

ORDER 139. ALISMACEÆ. Swampy herbs, with the leaves and scapes usually arising from a creeping rhizoma;

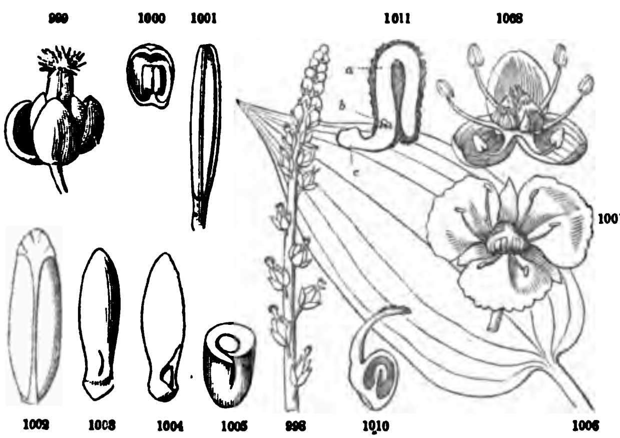


FIG. 998. Raceme or spike of Triglochin palustre. 999. Enlarged flower. 1000. A petal and stamen. 1001. The club-shaped capsule. 1002. A magnified seed, exhibiting the raphe and chalaza. 1003. Embryo of the same, showing the lateral slit just above the radicular end (444, where this structure is explained). 1004. Vertical section of the same passing through the slit, bringing the plumule to view. 1005. Cross section (more magnified), showing the cotyledon wrapped around the plumule.

FIG. 1006. Leaf, and 1007, flower of Alisma Plantago. 1008. More enlarged flower, with the petals removed. 1010. Carpel, with the ovary divided, showing the doubled ovule. 1011. Vertical section of the germinating seed of Alisma Damasonium: *a*, the cotyledon; *b*, the plumule; *c*, the protruding radicle.

the former either linear, or bearing a flat limb, which is ribbed or nerved, but the veinlets commonly reticulated. Flowers regular, perfect or polygamous, mostly in racemes or panicles. — Sepals three. Petals three. Seeds solitary in each carpel or cell, straight or curved, destitute of albumen.

Ex. Alisma (Water Plantain), Sagittaria (Arrowhead); belonging to the proper Alisma tribe, which has the seed (and consequently the embryo) curved or doubled upon itself. Triglochin and Scheuchzeria chiefly constitute the division JUNCAGINEÆ; where the seed and embryo are straight, and the petals (if present) greenish like the calyx.

Group 4. *Flowers with a simple or double perianth, which coheres with the lower part, or with the whole surface of the ovary. — Herbs.*

ORDER 140. HYDROCHARIDACEÆ consists of a few water-plants, distinguished by their regular perianth (usually having both calyx and corolla) adherent to the ovary, and numerous seeds without albumen. — *Ex.* Hydrocharis, Vallisneria, Udora.

ORDER 141. BURMANNIACEÆ consists of small (mostly tropical) annual herbs, with regular perfect flowers, three stamens, the one-celled (inferior) ovary with three parietal placentæ, and numerous seeds. — *Ex.* Burmannia, Apteria.

ORDER 142. ORCHIDACEÆ. Herbs, of varied aspect and form; distinguished from the other orders with an inferior ovary, and from all other plants, by their irregular flowers, with a perianth of six parts; their single fertile

---

ORDER BUTOMACEÆ consists of Butomus, Hydrocleis, &c.: plants resembling the Alisma tribe, but with a milky juice, and the numerous seeds attached to the whole inner surface of the carpels!

stamen (or in Cypripedium their two stamens) coherent with the style (composing the *column*); their pollen usually combined into two or more compact or regular masses (*pollinia*), or of the consistence and appearance of wax: the ovary one-celled, with three parietal placentæ, covered with numerous small seeds.

Ex. Orchis, Cypripedium (Ladies'-Slipper), Arethusa, &c. In the tropics many are Epiphytes (63, Fig. 66). Many are cultivated for their beauty and singularity. The tuberiferous roots are often filled with a very dense mucilaginous or glutinous substance (as those of our Aplectrum,

FIG. 1012. Orchis spectabilis: *a*, a separate flower. 1013. Column (somewhat magnified), from which the other parts are cut away: the two anther-cells opening and showing the pollen-masses. 1014. Magnified pollen-mass, with its stalk. 1015. Arethusa bulbosa. 1016. The column, enlarged: the anther terminal and opening by a lid. 1017. Magnified anther, with the lid removed, showing the two pollen-masses in each cell.

thence called Putty-root). Of this nature is the Salep of commerce, the produce of some unascertained species of Middle Asia. The fragrant *Vanilla* is the fleshy fruit of the West Indian Vanilla claviculata.

ORDER 143. ZINGIBERACEÆ consists of some tropical aromatic herbs, the nerves of their leaves diverging from a midrib; the adherent perianth irregular and triple (having a corolla of two series as well as a calyx); stamen one, free; the fruit a three-celled capsule or berry; the seeds several: with the embryo in a little sac at one extremity of the farinaceous albumen.

Ex. Zingiber (Ginger), Amomum (Cardamon). Stimulant and aromatic. Some afford a coloring matter (*Turmeric*). They are all showy plants.

ORDER 144. CANNACEÆ, which are equally tropical plants, differ from the preceding chiefly in the want of aroma, in the petaloid filaments of the single fertile and two sterile stamens; the latter with a one-celled anther, &c.

Ex. Maranta arundinacea (the *Arrow-root*) of the West Indies; the tubers of which are filled with pure starch.

ORDER 145. MUSACEÆ; tropical plants, of which the Banana or Plantain is the type, distinguished by their simple perianth and six perfect stamens. The fruit is most important in the tropics; the gigantic leaves used in thatching; and the fibres of Musa textilis form a valuable flax, from which India linen is made.

ORDER 146. BROMELIACEÆ consists of American and chiefly tropical plants; with rigid and dry channelled leaves, often with a scurfy surface, a perianth of three sepals and three petals, and six or more stamens; the seeds with mealy albumen. — *Ex.* Ananassa, the Pine-Apple; the fine fruit of which is formed by the consolidation of the imperfect flowers, bracts, and receptacle into a fleshy, suc-

culent mass. Tillandsia, the Black Moss or Long Moss, which, like most Bromelias, grows on the trunks and branches of trees in the warmer and humid parts of America, has the ovary free from the perianth.

ORDER 147. AMARYLLIDACEÆ. Bulbous plants (sometimes with fibrous roots), bearing showy flowers mostly on scapes. — Perianth regular or nearly so; the tube adherent to the ovary, and often produced above it, six-parted. Stamens six, distinct, with introrse anthers. Stigma undivided or three-lobed. Fruit a three-celled capsule or berry. Seeds with fleshy albumen.

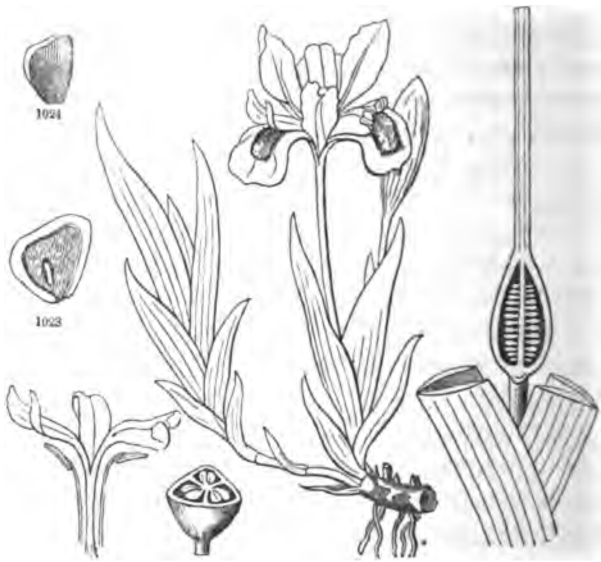
Ex. Amaryllis, Narcissus, Crinum, &c. The bulbs acrid, emetic, &c.: those of Hæmanthus (with whose juice the Hottentots poison their arrows) are extremely venomous. The fermented juice of Agave is the intoxicating *Pulque* of the Mexicans.

ORDER 148. HÆMODORACEÆ is composed of perennial herbs, with fibrous roots, equitant or ensiform leaves; which, with the stems and flowers, are commonly densely clothed with woolly hairs. — Perianth with the tube either nearly free from, or adherent to the three-celled ovary; the limb six-cleft, regular. Stamens six, or only three, with introrse anthers. Style and stigma single. Embryo in cartilaginous albumen. — *Ex.* Lachnanthes (Red-Root), Lophiola.

ORDER 149. IRIDACEÆ. Perennial herbs; the flower-stems springing from bulbs, corms, or rhizomas, rarely with fibrous roots, mostly with equitant leaves. Flowers regular or irregular, showy, often springing from a spathe. — Perianth with the tube adherent to the three-celled ovary, and usually elongated above it; the limb six-parted, in two series. Stamens three, distinct or monadelphous; the anthers extrorse! Stigmas three, dilated or petaloid! Seeds with hard albumen.

Ex. Iris, Crocus. The rootstocks, corms, &c., contain

starch, with some volatile acrid matter. ***Orris-root*** is the dried rhizoma of Iris florentina, of Southern Europe. ***Saffron*** is the dried orange stigmas of Crocus sativus.



ORDER 150. DIOSCOREACEÆ consists of a few twining plants; distinguished by their ribbed and netted-veined leaves, with distinct petioles, and by their inconspicuous diœcious flowers.—Perianth in the pistillate flowers adherent to the ovary; the limb six-cleft in two series. Stamens six. Ovary three-celled, with only one or two ovules in each cell: styles nearly distinct. Fruit often a three-winged capsule. Albumen cartilaginous.

FIG. 1019. Iris cristata. 1020. The summit of the style, petaloid stigmas, and stamens. 1021. Vertical section of the ovary (the equitant leaves cut away) and long tube of the perianth. 1022. Cross section of the pod. 1024. Seed. 1023. Enlarged section of the same, showing the embryo, &c.

Ex. Dioscorea. The tubers, filled with starch and mucilage (but more or less acrid until cooked), are *Yams*, an important article of food in tropical countries.

Group 5. *Flowers with a regular perianth, often in two series, which are similar and more or less petaloid, or rarely (in* Juncaceæ) *glumaceous, free from the ovary. Embryo inclosed in albumen. — Herbs, rarely climbing or shrubby plants.*

Order 151. SMILACEÆ. Herbs or shrubby plants, often climbing, with the veins or veinlets of the leaves reticulated. Flowers perfect or diœcious. — Perianth six-parted. Stamens six. Cells of the ovary and stigmas three. Berry few or many-seeded. Albumen hard.

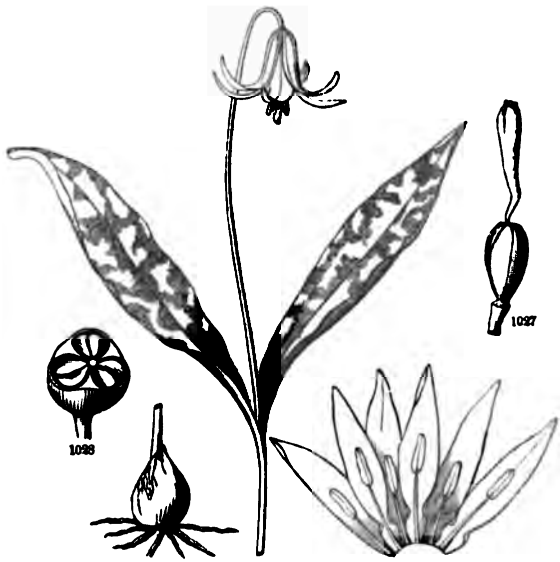
Ex. Smilax, (Greenbrier, Catbrier, &c.). *Sarsaparilla* of the shops consists of the roots of numerous species of Smilax, chiefly of tropical America.

Order 152. LILIACEÆ. Herbs, with the flower-stems springing from bulbs, tubers, or with fibrous or fascicled roots. Leaves simple, sheathing or clasping at the base. — Flowers regular, perfect. Perianth colored, mostly of six parts, or six-cleft. Stamens six: anthers tnrned inwards. Ovary three-celled; the styles united: stigma often three-lobed. Fruit capsular or fleshy, with several or numerous seeds in each cell. Albumen fleshy.

Ex. This large and widely diffused order comprises a great variety of forms: the Lily and Tulip represent one division; the Polianthes (Tuberose), a second; the Aloe and Yucca, a third; the Hyacinth, the Onion, &c. (Allium), the Asphodel, Asparagus, &c., a fourth. Acrid and often bitter principles prevail in the order, and are most concentrated in the bulbs, &c., which abound in starchy or mucilaginous matter, and are often edible when cooked. *Squills* are the bulbs of Scilla maritima of the South of Europe. *Aloes* is yielded by the succulent leaves of species of Aloe.

41 *

The original *Dragon's-blood* was derived from the juice of the famous Dragon-tree (Dracæna Draco) of the East.



ORDER 153. PONTEDERIACEÆ comprises a few aquatic plants, with the flowers, either solitary or spicate, arising from a spathe or from a fissure of the petiole; the six-cleft perianth persistent and withering, often adherent to the base of the three-celled ovary, and circinate in æstivation; the stamens three, and inserted on the throat of the perianth, or six, and unequal in situation. Ovules numerous; but the fruit often one-celled and one-seeded. — *Ex.* Pontederia (Pickerel-weed), Heteranthera, &c.

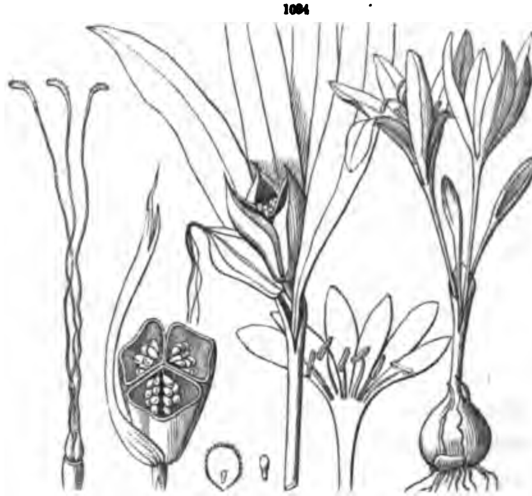
ORDER 154. MELANTHACEÆ. Herbs, with bulbs, corms, or fasciculated roots. — Perianth regular, in a double

Fig. 1025. Erythronium Americanum (Dog-tooth Violet, Adder's-tongue). 1026. Perianth laid open, with the stamens. 1027. The pistil. 1028. Cross section of the capsule.

series; the sepals and petals either distinct, or united below into a tube. Stamens six; the anthers turned outwards. Ovary three-celled, several seeded: styles distinct. Fruit a septicidal capsule. Albumen fleshy.

Ex. Colchicum (Fig. 1029), has a perianth with a long tube, arising from a subterranean ovary; it is also remarkable for flowering in the autumn, when it is leafless, ripening its fruit and producing its leaves the following spring. In

1034



1031 1035 1036 1030 1029

most of the order, the leaves of the perianth are uncombined; as in Veratrum (White Hellebore), Helonias, &c. Acrid and drastic poisonous plants, with more or less narcotic qualities; chiefly due to a peculiar alkaloid principle, named *Veratria*, which is largely extracted from the seeds of Sabadilla, or Cebadilla; the produce of Schœnocaulon officinale, &c., of the Mexican Andes.

FIG. 1029. Colchicum autumnale; a flowering plant. 1030. Perianth laid open. 1031. Pistil, with the long distinct styles. 1034. Leafy stem and fruit (capsule opening by septicidal dehiscence). 1035. Capsule divided transversely. 1036. Section of a seed, and a separate embryo.

ORDER 155. JUNCACEÆ. Herbaceous, mostly grass-like plants, often leafless: the small glumaceous flowers in clusters, cymes, or heads. — Perianth mostly dry, greenish or brownish, of six leaves (sepals and petals) in two series. Stamens six, or rarely three. Ovary three-celled, or one-celled from the placentæ not reaching the axis; their styles united into one: stigmas three. Capsule three-valved, few or many-seeded. Albumen fleshy. — *Ex.* Juncus (Rush).

Group 6. *Flowers with a double or imbricated perianth; the exterior (calyx) glumaceous or herbaceous; the interior with the ordinary texture of petals. Ovary free, one to three-celled. Seeds orthotropous; the embryo at the extremity of the albumen most remote from the hilum. — Herbs, often grass-like.*

ORDER 156. COMMELYNACEÆ, with usually sheathing leaves; distinguished from other Endogens (except Alismaceæ and Trillium) by the manifest distinction between the calyx and corolla; the former of three herbaceous sepals; the latter of as many delicate colored petals. Stamens six, or fewer: filaments often clothed with jointed hairs, hypogynous. Ovary two or three-celled; the styles united into one. Capsule few-seeded. — *Ex.* Commelyna, Tradescantia (Spider-wort). Mucilaginous plants.

ORDER 157. XYRIDACEÆ. Swampy, rush-like plants; with ensiform or filiform radical leaves, sheathing the base of a simple scape, which bears a head of flowers at the apex, imbricated with bracts. — Calyx of three glumaceous sepals, caducous. Petals three, with claws, more or less united into a monopetalous tube. Stamens six, inserted on the corolla; three of them bearing extrorse anthers, the others mere sterile filaments. Ovary one-celled, with three parietal placentæ, or three-celled: styles partly united: stigmas lobed. Capsule many-seeded. — *Ex.* Xyris.

ORDER 158. ERIOCAULONACEÆ. Swampy or aquatic herbs, with much the aspect and structure of the pre-

ceding; their leaves cellular or fleshy; their minute flowers (monœcious or diœcious) crowded, along with scales or hairs, into a very compact head: the corolla less petaloid than in Xyridaceæ; the six stamens often all perfect; the ovules and seeds solitary in each cell. — *Ex.* Eriocaulon.

Group 7. *Flowers imbricated with bracts (glumes, scales), and disposed in spikelets; but with no proper floral envelopes or perianth, except in the form of bristles or small rudimentary scales. Ovary one-celled, with a solitary ovule; in fruit an achenium or caryopsis. Embryo at the extremity of the albumen next the hilum. — Grasses, sedges, or rush-like plants.*

ORDER 159. CYPERACEÆ. Stems (*culms*) usually solid, cæspitose. Sheaths of the leaves entire. — Flowers

FIG. 1037. Scirpus triqueter, with its cluster of spikelets. 1038. A separate flower, enlarged, showing its rudimentary perianth of a few denticulate bristles,

one in the axil of each bract. Perianth none, or of a few bristles. Stamens mostly three, hypogynous. Styles two or three, more or less united. Fruit an achenium.

Ex. Cyperus, Scirpus, Carex. Sedge-Grasses. — The *papyrus* of the Egyptians was made from the stems of Cyperus Papyrus.

ORDER 160. GRAMINEÆ. Stems (*culms*) cylindrical, mostly hollow, and closed at the nodes. Sheaths of the leaves split or open. — Flowers in little spikelets, consisting of two-ranked imbricated bracts; of which the exterior are called *glumes;* and the two that immediately inclose each flower, *paleæ.* Perianth none, or in the form of very small and membranous hypogynous scales, from one to three in number, distinct or united (termed *squamulæ*, *squamellæ*, or *lodiculæ*). Stamens commonly three: anthers versatile. Styles or stigmas two; the latter feathery. Fruit a caryopsis (419). Embryo situated on the outside of the farinaceous albumen.

Ex. Agrostis, Phleum, Poa, Festuca, which are the principal meadow and pasture grasses: Oryza (Rice), Zea (Maize), Milium (Millet), Avena (the Oat), Triticum (Wheat), Secale (Rye), Hordeum (Barley), are the chief cereal plants, cultivated for their farinaceous seeds. This universally diffused order, one of the largest of the vegetable kingdom, is doubtless the most important: the floury albumen of the seeds, and the nutritious herbage, constituting the chief support of man and the herbivorous animals.

its three stamens, and pistil with a three-cleft style: *a*, section of the seed, showing the minute embryo. 1039. Carex Careyana, reduced in size (flowers monœcious, the two kinds in different spikes). 1040. Stem, with the staminate and upper pistillate spike, of the size of nature. 1041. A scale of the staminate spike, with the flower (consisting merely of three stamens) in its axil. 1042. Magnified pistillate flower, with its scale or bract: the ovary inclosed in a kind of sac (*perigynium*), formed by the union of two bractlets. 1043. Cross section of the perigynium; with the pistil, *p*, removed. 1044. Vertical section of the achenium, showing the seed.

No unwholesome properties are known in the family, except in the seeds of Lolium temulentum, which are deleterious. The *Ergot*, or Spurred Rye, forms no real exception to this rule, as it is caused by parasitic fungus. — The stems of grasses frequently contain sugar in considerable quantity; especially in the few instances where it is solid, as in the Maize, and more largely in the Sugar-Cane (Saccharum officinarum), which affords the principal supply of this article.

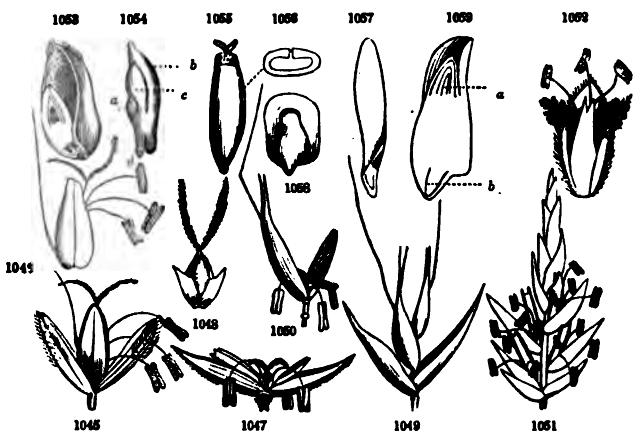


FIG. 1045. One-flowered spikelet or locusta of Alopecurus, with the glumes separated. 1046. Same with the glumes removed: an *awn* on the back of the outer palea. 1047. One-flowered spikelet of an Agrostis. 1048. Pistil of a grass, showing the two feathery stigmas, and the two hypogynous scales or squamulæ (representing the perianth). 1049. Two-flowered spikelet of an Avena; with the glumes spreading. 1050. One of the flowers with its paleæ; the exterior pointed, with two bristles or cusps at the apex, and with a bent awn on the back. 1051. Many-flowered spikelet of Glyceria fluitans. 1052. An enlarged separate flower of the same, seen from within, showing the inner palea, &c. 1053. The fruit (caryopsis) of the Wheat, with an oblique section through the integuments of the embryo, which is exterior to the albumen. 1054. Detached magnified embryo: *a*, the imperfect lower cotyledon; *b*, the large cotyledon; *c*, the plumule; *d*, the radicle. 1055. The caryopsis of Hordeum (Barley). 1056. A cross section. 1057. A vertical section, showing the external embryo at the base. 1058. Magnified detached embryo, with its broad cotyledon and the plumule. 1059. More magnified vertical section of the same: *a*, the plumule; *b*, the radicle.

Series II.—Flowerless or Cryptogamous Plants.

As our limits forbid our giving an explicit systematic account of these lower orders of the vegetable kingdom, we can only refer the student to the general view of their structure and economy already given in Chapter XII. of Part I.

They constitute the following orders, namely,

Order 161. EQUISETACEÆ, the Scouring Rushes, &c., *vide* p. 272.

Order 162. LYCOPODIACEÆ, the Club-moss Tribe, p. 274.

Order 163. FILICES, the Ferns, p. 275.

Order 164. MARSILEACEÆ, the Pepperworts, &c., p. 277.

Order 165. MUSCI, the Mosses, p. 277.

Order 166. HEPATICÆ, the Liverworts, p. 279.

Order 167. LICHENS, the Lichens, p. 281.

Order 168. FUNGI, the Mushroom Tribe, p. 283.

Order 169. CHARACEÆ, the Chara Tribe, p. 286.

Order 170. ALGÆ, the Seaweeds, &c., p. 287.

APPENDIX.

1. Of the Signs and Abbreviations usually employed in Botanical Writings.

Linnæus adopted the following signs for designating the duration of a plant, namely:

☉ An annual plant.
♂ A biennial plant.
♃ A perennial plant.
♄ A shrub or tree.

Among the signs recently introduced, the following have come into general use:

① An annual plant.
② A biennial plant.
♃ A perennial herb.
♄ A plant with a woody stem.
♂ A staminate flower, or plant.
♀ A pistillate flower, or plant.
☿ A perfect flower, or a plant bearing perfect flowers.
! The exclamation point is employed as the counterpart of the note of interrogation. When it follows the name of an author appended to the name of a plant, it imports that an authentic specimen of the plant in question, under this name, has been examined by the writer: when it is appended to a locality, it signifies that the writer has seen, or himself collected specimens of the plant from that locality, &c.

? The note of interrogation is similarly employed in case of doubt or uncertainty; and is affixed either to a generic or specific name, or that of an author or locality cited.

* As used by De Candolle, indicates that a good description will be found at the reference to which it is appended. It is not in common use.

Those abbreviations of the names of organs which are commonly employed, such as *Cal.* for calyx, *Cor.* for corolla, *Fl.* for flower, *Fr.* for fruit, *Gen.* for genus, *Hab.* for habitat, *Herb.* for herbarium, *Hort.* for garden, *Mus.* for Museum, *Ord.* for order, *Rad.* (Radix) for root, *Syn.* for synonymy, *Sp.* for species, *Var.* for variety, &c., scarcely require explanation.

V. sp. denotes in general terms that the writer has seen the plant under consideration.

V. s. c. (*Vidi siccam cultam*), that a dried specimen of a cultivated plant has been examined.

V. s. s. (*Vidi siccam spontaneam*), that a dried specimen of the wild plant has been examined.

V. v. c. (*Vidi vivam cultam*), that the living cultivated plant has been under examination.

V. v. s. (*Vidi vivam spontaneam*), that the wild plant has been examined in a living state.

The names of authors, when of more than one syllable, are commonly abridged by writing the first syllable and the first letter, or the first consonant, of the second. Thus, *Linn.* is the customary abbreviation for Linnæus; *Juss.* for Jussieu; *Willd.* for Willdenow; *Muhl.* for Muhlenberg; *Michx.* for Michaux; *Rich.* for Richard; *De Cand.*, or *DC.*, for De Candolle; *Hook.* for Hooker; *Endl.* for Endlicher; *Lindl.* for Lindley, &c.

2. Of Collecting and Preserving Plants.

1. The botanist's collection of specimens of plants, preserved by drying under pressure in folds of paper, is termed an *Hortus Siccus*, or commonly an *Herbarium*.

2. A complete specimen consists of one or more shoots bearing the leaves, flowers, and fruit; and, in case of herbaceous plants, a portion of the root is also desirable.

3. Fruits and seeds which are too large to accompany the dried specimens, or which would be injured by compression, with sections of wood, &c., should be separately preserved in cabinets.

4. Specimens for the herbarium should be gathered if possible in a dry day; and carried either in a close tin box, as is the common practice, or in a strong portfolio, containing a quire or more of firm paper, with a few loose sheets of blotting paper to receive delicate plants. They are to be dried, under strong pressure (but without crushing their parts), between dryers composed of six to ten thicknesses of bibulous paper; which should be changed daily, or even more frequently, until all the moisture is extracted from the plants; — a period which varies in different species from two or three days, to a week.

5. The dried specimens, properly ticketed with the name, locality, &c., and arranged under their respective genera and orders, are preserved in the herbarium, either in separate double sheets, or with each species attached by glue or otherwise to a half-sheet of strong white paper, with the name written on one corner. These are collected in folios, or else lie flat (as is the English mode) in parcels of convenient size, received into compartments of a cabinet, with close doors, and kept in a perfectly dry place.

6. The seeds of plants intended for cultivation, which are to be transported to a distance before being committed to the earth, should first be dried in the sun, wrapped in coarse paper, and preserved in a dry state. They should not be packed in close boxes, at least so long as there is danger of the accumulation of moisture.

7. Roots, shrubs, &c., designed for cultivation, should be taken from the ground at the close of their annual vegetation, or early in the spring before growth recommences, and packed in successive layers of slightly damp (but not wet) Peat-moss (Sphagnum). Succulent plants, however, such as the Cactus, should be packed in dry sand.

8. Plants in a growing state can only be safely transported to a considerable distance, especially by sea, in the closely glazed cases invented by Mr. Ward (page 141, note); * where they are provided with the requisite moisture, while they are fully exposed to the light.

---

* On the Growth of Plants in closely glazed Cases; by N. B. Ward, F. L. S., London, 1842.

INDEX

AND GENERAL GLOSSARY OF BOTANICAL TERMS.

*** The accent, in this Index, is used in the manner employed by Loudon. When the accented vowel is joined, as it were, to the following consonant, the mark of accentuation is turned forwards, or to the right; as in Vál-vular. When the accented syllable is long, and independent of the ensuing consonant, the mark is turned backwards, or to the left; as in Và-siform.

FINIS.